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27 Dazzling Images of Moons, Planets, and Nebulae in Another Dimension

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Combat Duty with NASA's Dan Goldin

Eta Carinae Nebula

LX50

Advanced technology at the most affordable prices *ever.*

- **Battery-Powered, Completely Cordless Operation!** Meade LX50 models operate for more than 50 hours from six AA-size batteries inserted through the telescope's control panel. Or use the standard-equipment 25 ft. cord to power the telescope directly from any auto cigarette lighter plug.

- **Standard-Equipment Declination Motor and Hand Controller:** Plug the hand controller into the LX50 control panel and you're ready for full dual-axis drive capability at any of 4 photo-guide or microslew speeds: 2x, 8x, 16x, or 32x, plus quartz-controlled sidereal-rate tracking in R.A. Switch speeds instantly using the speed-control button on the hand controller. Dual-axis drive rate is indicated by a red LED.

- **Multi-Function Control Panel:** Includes connectors for CCD autoguiders; for the standard-equipment Declination motor; and for the optional Magellan II Computer-Corrector *(below)*. A North-South switch permits telescope operation anywhere in the world.

- **Super Multi-Coated Optics:** The exact same EMC super multi-coated optical tube assemblies included with Meade LX200 models.

- **Massive LX200-type Fork Mounts:** Meade LX50 mounts are manufactured of the same virgin aluminum castings as Meade LX200 Schmidt-Cassegrains. Massive, rigid mountings that include the Meade LX worm-gear drive system with low periodic error for advanced photographic or CCD imaging applications. *No competing mid-priced equatorial mountings even come close.*

SPECIFICATIONS: 7", 8", and 10" LX50's—Each complete telescope includes 8" or 10" f/10 Schmidt-Cassegrain or 7" f/15 Maksutov-Cassegrain optical tube assembly with EMC super multi-coatings; heavy-duty LX200-type fork mount; 5.75" LX worm gear system in R.A.; multi-function control panel; DC servo Declination motor; manual and electric slow-motion controls on both axes; setting circles on both axes; keypad hand controller; 4-speed drive controls on both axes; battery compartment accepting six (user-supplied) AA-size batteries; 25 ft. power cord for telescope operation from 12v. auto cigarette lighter plug; 6 x 30mm (7" and 8" models) or 8 x 50mm (10") viewfinder; 1.25" diagonal prism; MA25mm multi-coated eyepiece (1.25"); standard equatorial wedge with elevation scale, bubble level, and azimuth control; complete operating instructions.

8" LX50 Schmidt-Cassegrain	**$1395.**
10" LX50 Schmidt-Cassegrain	**1695.**
7" LX50 Maksutov-Cassegrain	**1795.**
Variable-Height Field Tripod	**295.**
7" Maksutov-Cassegrain Tube Ass'y	**1295.**

Packing and shipping in the 48 states: 8"—$105; 10"—$145; 7"—$125; 7" Tube Assembly—$65.

Meade Magellan™ II Computer-Corrector for LX50 Telescopes: Plug the Magellan II into the control panel of your LX50 and enjoy an incredible range of advanced capabilities. ■ Fast manual slewing to any object, either from input RA and Dec or from the 12,218-object database. ■ High-resolution 4096-pulse encoders (5.3 arc-minute precision), concealed in special LX50 encoder compartments. ■ Large 32-character, red-back-lighted display. ■ Quick 2-star alignment. ■ Four-speed (2x, 8x, 16x, 32x sidereal) dual-axis drive corrector/microslewing system.

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COMPUTER - CORRECTOR
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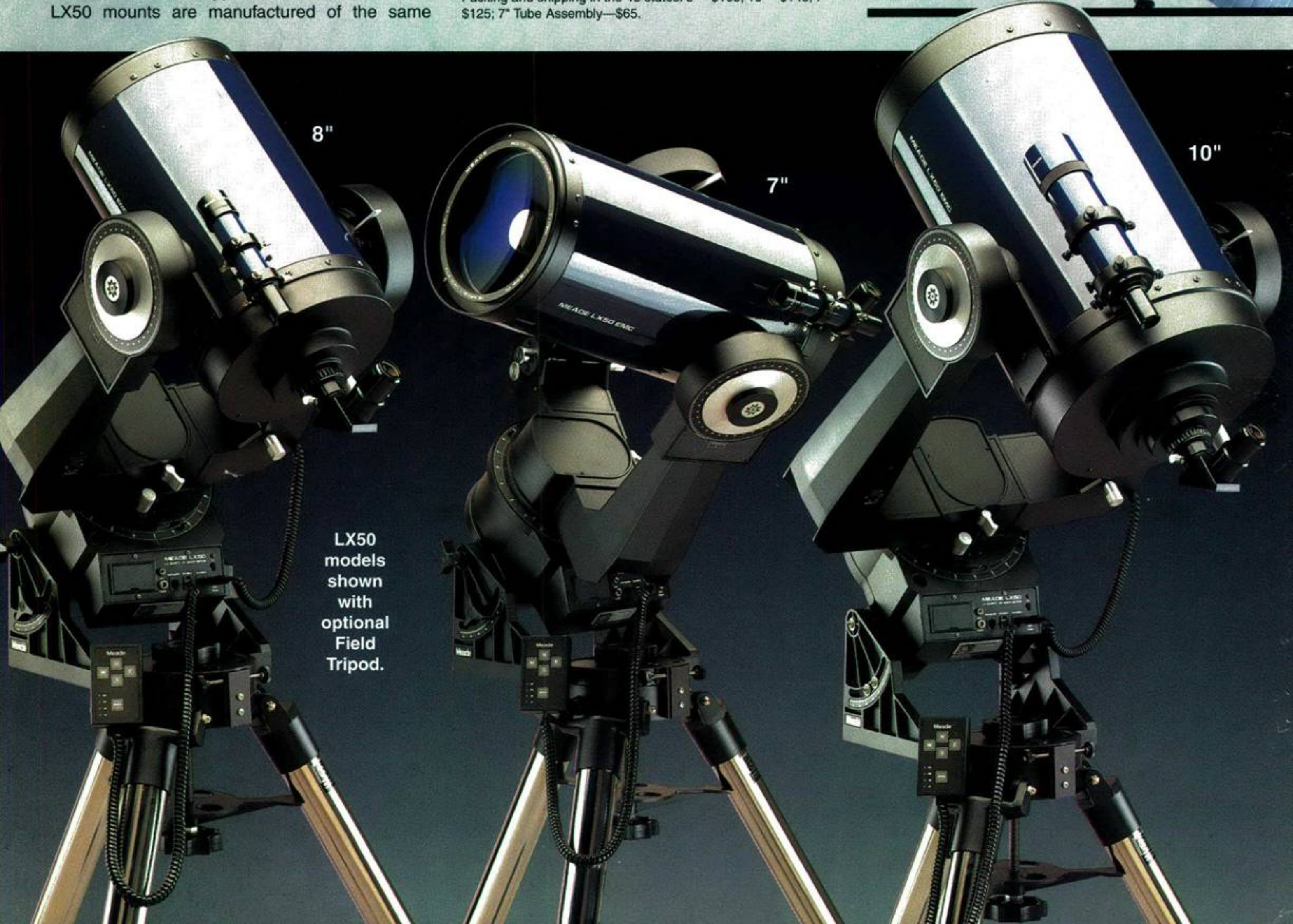
only $495!

#2024: Magellan II for LX50's—Includes Magellan II hand controller *(right)*; encoders for both axes; all required mounting hardware. Installs to any LX50 in minutes. **$495.** + $15 packing and shipping in the 48 states.



LX50 models shown with optional Field Tripod.

The largest-selling serious telescopes in the world.

LX200

In virtually every country in the world where serious telescopes are sold, more Meade LX200's are sold than all competing models *combined*. Consider these *standard-equipment* specifications:

- **Superb Optics:** LX200 diffraction-limited imaging capabilities are a legend in the industry; we regularly receive reports stating that optical performance approaches that of a fine *ED* apochromatic lens.
- **Automatic GO TO Capability:** Meade LX200's are *the only commercial telescopes ever manufactured* that automatically GO TO any input R.A. and Dec., or to any of 64,359 objects in the onboard database, *to a precision of one arc-minute or better.*

8" LX200 Schmidt-Cassegrain	**$2795.**
10" LX200 Schmidt-Cassegrain	**3195.**
12" LX200 Schmidt-Cassegrain	**4495.**
7" LX200 Maksutov-Cassegrain	**3295.**

Packing and shipping in the 48 states: 8"—$105; 10"—$145; 12"—$215; 7"—$125.

- **Meade LX200 High-Precision Pointing™** is so precise it permits the positioning of *every* selected object on *every* commercially-available CCD chip *every* time, automatically — *a feat that no other telescope priced under $40,000 can accomplish.*
- **Permanently-Programmable Smart Drive™** routinely achieves 5 arc. sec. periodic error, an observatory standard.
- **9-Speed Dual-Axis Electronics:** Electronics that cover every possible contingency of telescope positioning—from 2x photo-guide, to 32x image centering, to 8°/sec. slewing across the sky, as well as 6 other dual-axis drive speeds in between.
- **Field Operation:** No other telescopes of such incredible capabilities transport so readily for field operation. The optional #1812 Electronic DC Adapter (a compact 4 oz. unit) allows for field powering directly from an automobile cigarette lighter plug.

SPECIFICATIONS: 7", 8", 10", and 12" LX200's—Each complete telescope includes 8" or 10" (f/6.3 or f/10) or 12" f/10 Schmidt-Cassegrain or 7" f/15 Maksutov-Cassegrain optical tube assembly with EMC super multi-coatings; heavy-duty fork mount with 4" polar ball bearing, dual-axis 5.75" worm gears, and multi-function control panel; manual and electric slow-motion controls on both axes; keypad hand controller with digital readout display, permanently programmable Smart Drive, 9-speed drive controls on both axes (7-speed on 12"), High-Precision Pointing, and GO TO controller; 64,359-object onboard celestial software library; 25 ft. power cord and adapter for telescope operation from 115v.AC; 8 x 50mm viewfinder; 1.25" diagonal prism (7", 8", 10") or 2" diagonal mirror with 1.25" adapter (12"); Series 4000 Super Plössl 26mm eyepiece; standard field tripod (7", 8", 10") or giant field tripod (12"); operating instructions.

8"
7"
10"
12"
MEADE LX200 EMC
Meade

Write, call, or fax Meade Instruments for your free copy of the 100-page Meade General Catalog.

Prices shown are suggested U.S. mail-order retail prices.

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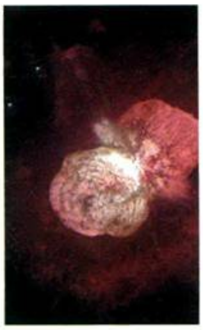

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COVER PHOTO: Jon Morse (Univ. of Colorado), Kris Davidson (Univ. of Minnesota), and NASA

FEATURES

36 **Ideas That Didn't Work Out**
The history of astronomy has witnessed the birth of many innovative ideas, but not all turned out to be right.

40 **Into Battle with NASA's Chief**
NASA Administrator Dan Goldin's vision of "faster, cheaper, better" has changed the way we explore space. *Andrew Lawler.*

COVER

49 **Take a Deeper Look at Your Universe**
Strap on your 3-D glasses and watch *Astronomy* come to life as we present three stories filled with wondrous 3-D images.

50 **Red Planet Rendezvous**
Stunning images have already begun to flow from Mars Global Surveyor, a mission sure to rewrite the book on the past climate of Mars. *William K. Hartmann.*

54 **The Universe in 3-D**
From Earth to the planets to the galaxy and beyond, feast your eyes on a glittering gallery of three-dimensional images.

61 **Pathfinder's 3-D Extravaganza**
To the delight of planetary scientists, Mars Pathfinder landed where a vast flood deposited rocks from all over. *Josh Rogan.*

82 **Seeing into Violent Corners**
Break out your telescope and explore the brilliant stars, supernova remnants, active galaxies, and quasars that populate our energetic universe. *Alan Goldstein.*

86 **The Call of Mt. Pinos**
Whether you want to image the sky or just view its wonders, this is the place to be in Southern California. *Tony Hallas.*

94 **Ask Astro**
We answers your questions about the science and hobby.

40 Combat Duty with NASA's Dan Goldin

Bill Ingalls/NASA

86 The Call of Mt. Pinos

Tony Hallas

54 3-D Blowout

Schenk, Gwynn, Tutor; 3-D Tour of the Solar System; LPI

82 How to View Cosmic Danger

Jack Newton

DEPARTMENTS

24 AstroNews Erich Karkoschka (Univ. of Arizona) and NASA

6 Behind the Scenes
- Grab Your 3-D Glasses and Follow Me

16 Talking Back

24 AstroNews
- A Black Hole Erupts
- No Martian Microfossils?
- Magnetic Carpet May Heat Sun's Corona
- Hubble Views Uranus
- Einstein Confirmed
- Stars Merge into One
- Asteroid Shares Orbit with Earth
- An Impact on the Weather

70 Sky Show
- Mercury appears at its evening best in March, but the real highlights of the month come when the moon passes close to Venus and Jupiter. *Martin Ratcliffe and Alister Ling.*

98 Star Stuff

Products
- Equalizer Adapter
- Deluxe Telescope Mount
- Mars Pathfinder Mission Mousepad
- Starlight Xpress MX5 CCD Camera
- Planetary Nebula Filter

Books
- Portraits of Discovery
- Destination Mars, in Art, Myth, and Science
- McGraw-Hill Encyclopedia of Science and Technology

Bytes
- 3-D Tour of the Solar System
- Introduction to Archeoastronomy

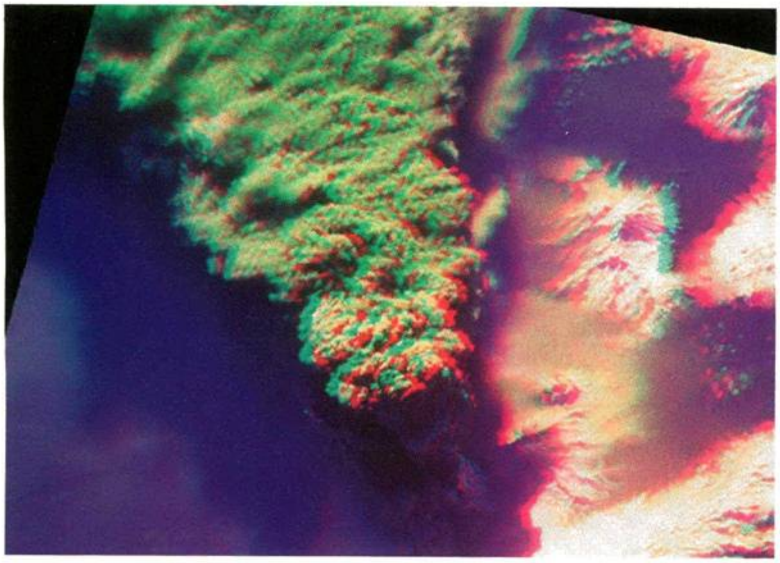
114 Looking Ahead

115 Resources

120 Advertiser Index

121 Hot Shots
- Austrian Eyes on the Sky

128 Ultimate Exposure



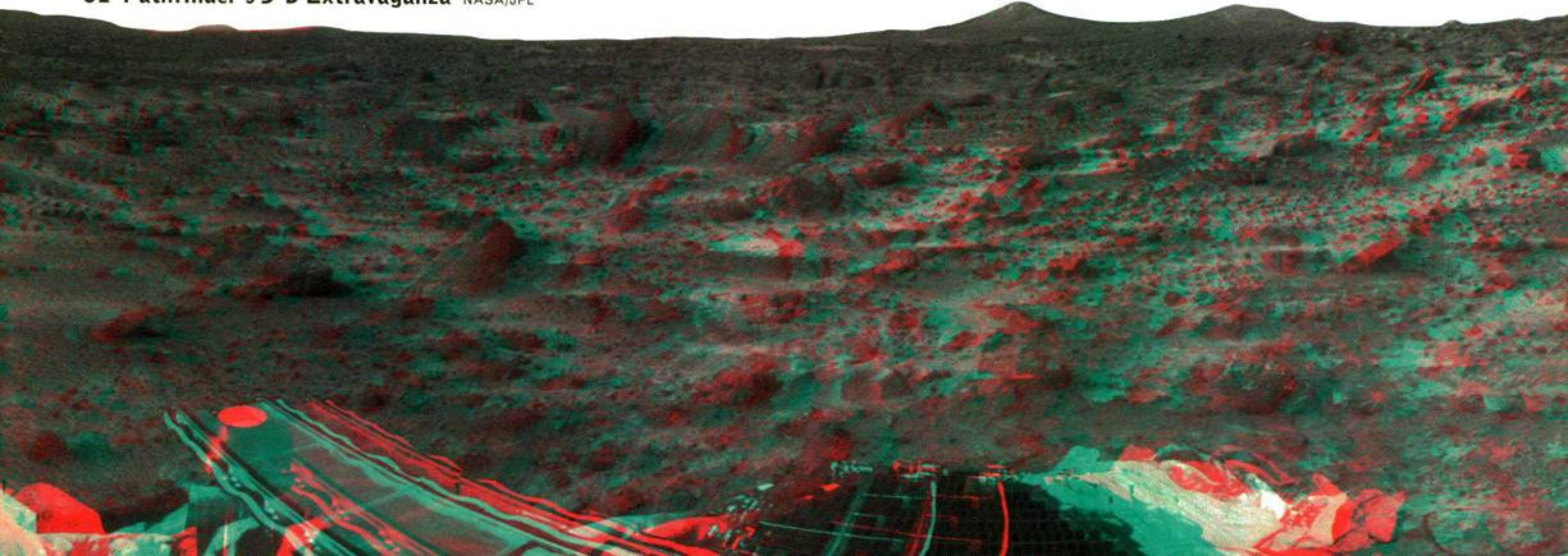
54 3-D Blowout

Schenk, Gwynn, Tutor; 3-D Tour of the Solar System; LPI

94 Ask Astro

NASA/JPL

61 Pathfinder's 3-D Extravaganza NASA/JPL



BY BONNIE BILYEU GORDON

Grab Your 3-D Glasses and Follow Me

Turn to page 49 and begin a unique journey through 17 3-D enriched pages of *Astronomy*. Find your two free pair of 3-D glasses inserted between pages 50 and 51. Read the stories too. They'll tell you what's freshest in the discoveries coming from the Mars Pathfinder trip and the Global Surveyor's orbit. This 3-D presentation is the big item this issue, but it's by no means the only important story.

Among lots of other rich topics, look for the story of NASA's top administrator Dan Goldin. Follow him through a day of combat with Congressional leaders, beyond-the-Beltway NASA employees, and those perennial big spenders, scientists, while he works to invent faster, cheaper, better missions to space. Under his direction, NASA has changed its slightly tattered image by leaving behind the colossal budgets and colossal flops of the 1980s and engineering more limited but inventive and successful expeditions that have riveted public attention. Meet the man who has mattered most in this transformation, brought to you by a man who knows him well. Andrew Lawler, who covers NASA and Goldin regularly for *Science* magazine, wrote the profile that begins on page 40.

Astronomy: Rebecca Saliture

***Astronomy* staff members delight in 3-D images while selecting their favorites for this special issue.**

And for something completely different, casual, and filled with joy, turn to the story of a place in California known to only a few. Astrophotographer Tony Hallas, one of *Astronomy*'s favorite shooters, has written about one of his favorite sites, Mt. Pinos, where many of the world's best astrophotographers capture images. And of course an important reason to run such a story is to showcase some of Tony's own photos, beginning on page 86.

Welcome to what we believe is a very special issue.

Astronomy®

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4" f/9 Achromatic
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— **$1295.**

MEADE 500-Series

Experience all of the high-resolution optical performance and mechanical precision of a MEADE reflector, refractor, or Schmidt-Cassegrain, at a moderate pricing level. Each complete 500-Series model includes the all-new MEADE LXD 500 equatorial mount with dual-axis worm gears, engraved setting circles, micrometric slow-motion controls in RA and Dec, rigid aluminum tripod, and a full complement of accessories. Choose from among five models the one that's right for your budget and observing requirements. *For complete details send for your free copy of Meade Bulletin 500.* Optional systems for Meade 500-Series telescopes include:

Shown with optional #1708 Computer Drive System

#1701 Single-Axis RA Drive System	**$145.**
#1702 Dual-Axis Drive System, with 4-speed hand controller	**195.**
#1708 Computer Drive System, with LX200-type hand controller, 4°/second slewing, Smart Drive, and 64,359-object database.	**795.**
#812 Polar Alignment Finder	**49.**

Prices shown are suggested U.S. national mail-order retail prices.
Packing and shipping: 4" models—$55; 4.5" and 5"—$45; 8"—$65.

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Meade Pictor 208XT
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complete **$495**

Meade Pictor 216XT
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complete **$695**

Meade Pictor 416XT
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complete **$1695**

includes $800 Meade CCD Equipment System

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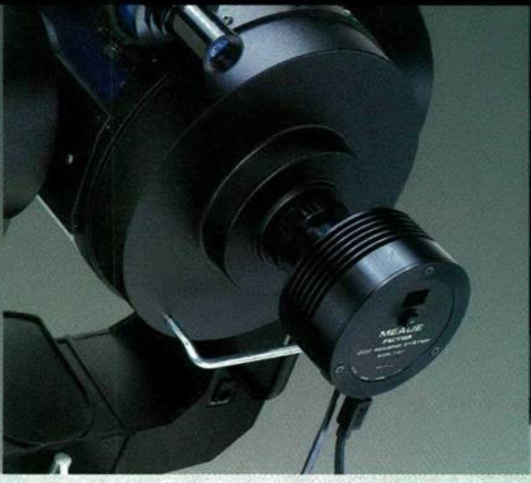
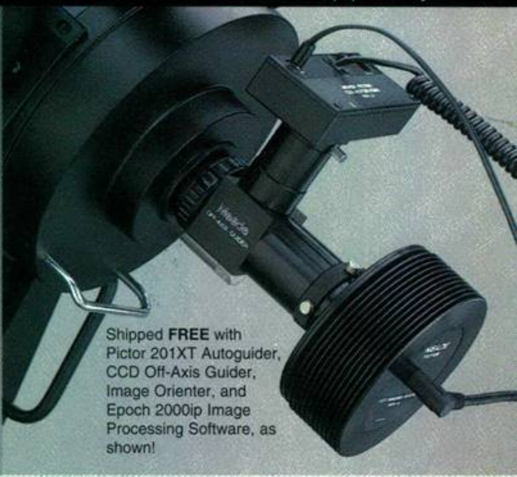
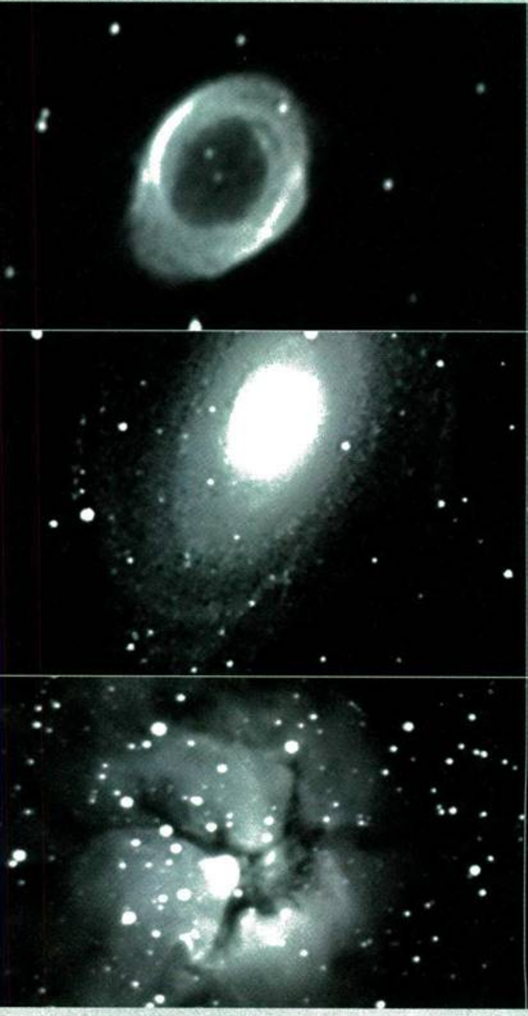


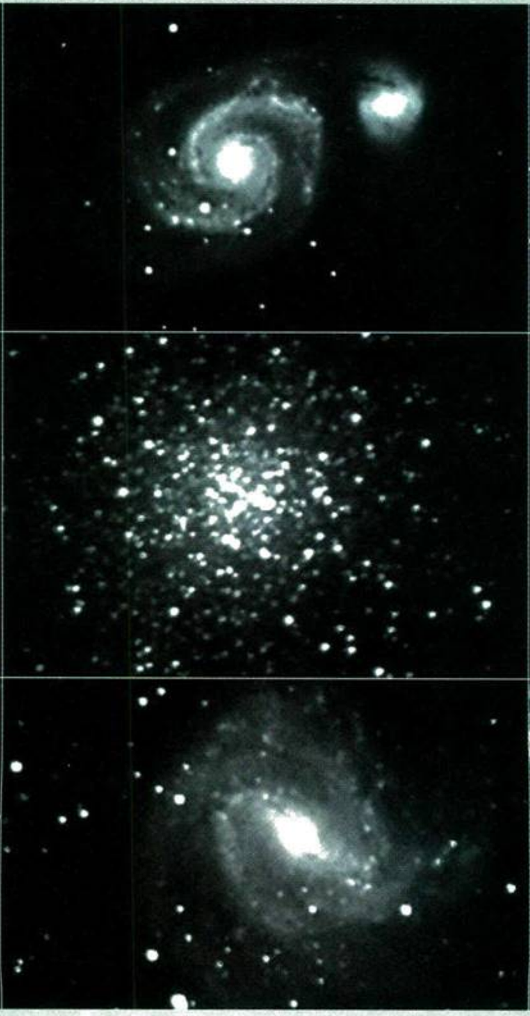


Shipped **FREE** with Pictor 201XT Autoguider, CCD Off-Axis Guider, Image Orienter, and Epoch 2000ip Image Processing Software, as shown!

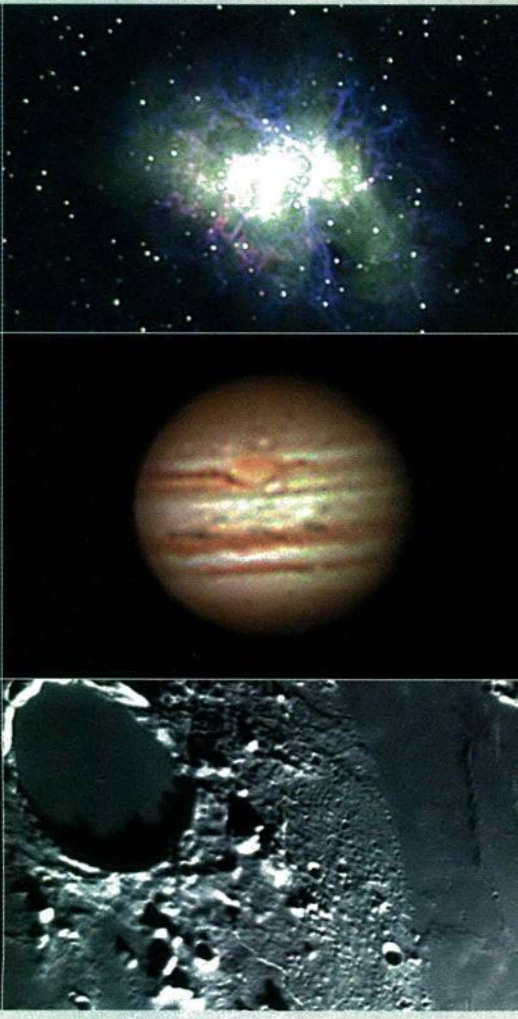
Revolutionary Meade Pictor CCD's are now the world's largest-selling autoguiders and imagers for the amateur astronomer. No other electronic imaging systems offer such an incredible range of capabilities at such amazing price levels. At only **$495** the **Pictor 208XT** produces on the PC display fine, high-resolution 8-bit images *in seconds* of the Moon and planets, or, in 2 or 3 minutes, of thousands of deep-space objects. At **$695** the **Pictor 216XT** enables advanced 16-bit imaging and is *by far* the finest autoguider/imager ever made available at under-$1000. At **$1695** the **Pictor 416XT** permits professional-level imaging capability for the amateur astronomer: an electronic camera capable of producing with amateur telescopes images of the Moon, planets, and deep-space that match or exceed the photographic images obtained with many observatory telescopes. All models are available for immediate shipment. ***For complete information on Meade CCD imaging systems write, call, or fax for your free copy of the 100-page Meade General Catalog.***



Pictor 208XT images *(top to bottom):* Ring Nebula (M57), 25" reflector, Jack Newton; Galaxy (M81) in Ursa Major, 12" LX200, Scott Roberts; Trifid Nebula (M20), 8" LX200, John Hoot.



Pictor 216XT images: Whirlpool Galaxy (M51), 12" LX200, John Hoot; Globular Cluster (M13), 25" reflector, Jack Newton; Galaxy (M83) in Hydra, 12" LX200, Scott Roberts.



Pictor 416XT images: Crab Nebula (M1), 25" reflector, Jack Newton; Jupiter, 10" LX200 with Stellar Products AO-2 seeing adapter, Dr. Donald Bruns; Moon (crater Plato), 16" f/6 reflector, Dr. Donald Parker.

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MEADE ETX

90mm Maksutov-Cassegrain

Meade ETX Astro Telescope. Shown with optional #64 Photo Adapter.

SPECIFICATIONS: ETX Astro Telescope—Includes Maksutov-Cassegrain optical tube assembly (D = 90mm, F = 1250mm, f/13.8) with EMC super multi-coatings; internal flip-mirror system for either straight-through or 90° observing position; equatorial fork mount with slow-motion controls, locks, and setting circles in R.A. and Dec; table tripod with elevation scale on center tripod leg; motor drive system with internal battery compartment accepting three (user-supplied) AA-size batteries; 8 x 21mm achromatic erect-image viewfinder; Series 4000 Super Plössl 26mm eyepiece (1.25"); operating instructions. *Net weight 9 lbs.* $595*
(+ $20 packing and shipping in the 48 states)
*Suggested U.S. mail-order retail price.

Now you can have diffraction-limited imaging and ultraportability ...at only *$595*, *complete!*

The revolutionary Meade ETX goes anywhere with you at a moment's notice and presents the finest optical images ever made available in an ultraportable telescope.

Optical System: Manufactured at the Meade Irvine, California facility, ETX diffraction-limited optics produce images so high in contrast, brightness, and resolution that the ETX consistently outperforms telescopes of much larger apertures. **Equatorial Fork Mount:** Precise polar alignment in *seconds*, just by extending the center tripod leg to read your latitude on the inscribed scale. **Cordless Motor Drive:** The internal drive system operates from 3 AA-size batteries that power the motor drive for more than 50 hours. A North-South switch permits operation anywhere in the world. **Flip-Mirror System:** Flip the internal optical flat mirror "up" for 90° observing; flip the mirror "down" for terrestrial observing with the optional #932 45° Erecting Prism or for photography with the optional #64 Photo Adapter. **Standard accessories** include a Series 4000 Super Plössl 26mm eyepiece and 8 x 21mm erect-image viewfinder.

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STARFINDER DOBSONIANS

No other competing Dobsonians include this listing of *standard-equipment* features:

Primary and Secondary Mirrors of Low-Expansion Pyrex® Glass: Unlike the plate glass optics of other Dobsonians that can become thermally unstable, all Meade Dobsonian optics are made of Grade-A fine-annealed Pyrex glass — the exact same professional-quality optics used on Meade Starfinder Equatorials.

Rigid, Durable, Beautiful Dobsonian Mountings, manufactured of cabinet-quality materials, provide extremely smooth motions of the telescope in both altitude and azimuth. Both telescope axes ride on zero-backlash Teflon/Nylon bearings, facilitating the quick location and easy tracking of celestial objects.

Full-Size 1.25" Rack-and-Pinion Focuser: For smooth, precise focusing of the image without wobble or backlash. Focus travel is 2.6"; accepts 1.25" eyepieces.

4-Vane Steel Secondary Mirror System: Permits locked-in support and precise centration and alignment of the secondary mirror.

Multi-Coated MA25mm Eyepiece (1.25"): The Meade Modified Achromatic 25mm eyepiece yields sharp, high-resolution imaging to the field edge.

5 x 24mm Viewfinder: Included with all Starfinder Dobsonian models for quick object-location in the main telescope. With crosshair eyepiece and 2-ring bracket.

Optical Tubes: Starfinder Dobsonians include the same strong, spiral-wound Sonotube™ optical tubes used on Starfinder Equatorials *(right),* tubes with excellent insulating characteristics that reduce internal thermal currents to an absolute minimum.

Performance! *Meade Starfinder Dobsonians and Equatorials are the largest-selling Newtonian reflectors of their apertures in the world.* Every Starfinder model opens up the skies to an extremely wide range of serious visual observing; all 110 Messier objects, thousands of NGC objects — nebulae, galaxies, star clusters, in all their variations of form, color, and extent, as well as the Moon and planets in stunning high-resolution detail. Starfinder Dobsonians are telescopes for visual observing; motor-driven Starfinder Equatorials may be used, in addition, for lunar and planetary photography, and even for limited deep-space photography.

Packing & UPS Shipping Charges to any address in the 48 states: 6"—$39; 8"—$49; 10"—$69; 12.5"—$79; 16"—$45 packing, shipped truck freight collect.

Dobsonian Deluxe Accessory Package
only $49.95!

Outfit your Meade Dobsonian with all of the most popular accessories for advanced observing. At the time you order any Dobsonian model, specify the following Deluxe Accessory Package for your telescope, in place of the standard-equipment focuser, viewfinder, and eyepiece, ***for a total of only $49.95 additional:***

1 - **Meade #77 2" Giant Rack-and-Pinion Focuser,** with machined aluminum eyepiece-holders for both 2" and 1.25" eyepieces; includes drawtube lock and 2.6" focuser travel. *(reg. $59.95)*

1 - **Meade #637 6 x 30mm Achromatic Viewfinder,** with wide 7° field; 2-ring metal bracket. *(reg. $49.95)*

3 - **Meade MA9mm, 12mm, and 25mm** multi-coated eyepieces, 1.25" barrel — eyepieces for the full range of lunar, planetary, and deep-space observing. *(reg. $37.95 each)*

Purchased separately, the Deluxe Accessory Package sells for $223.75!

Meade Magellan I Telescope Computer System

Attach the optional Magellan I Telescope Computer System to your Starfinder Dobsonian and finding any of 12,218 celestial objects, or *any* object of known R.A. and Dec., is almost as easy as pointing the telescope! Magellan I's database includes the following objects:

7,840	NGC objects; the complete NGC catalog
4,093	IC objects from the Index Catalog
125	user-defined objects
110	Messier objects; the complete catalog
42	alignment stars for the Magellan system
8	major planets, from Mercury to Pluto
12,218	objects, total

MEADE
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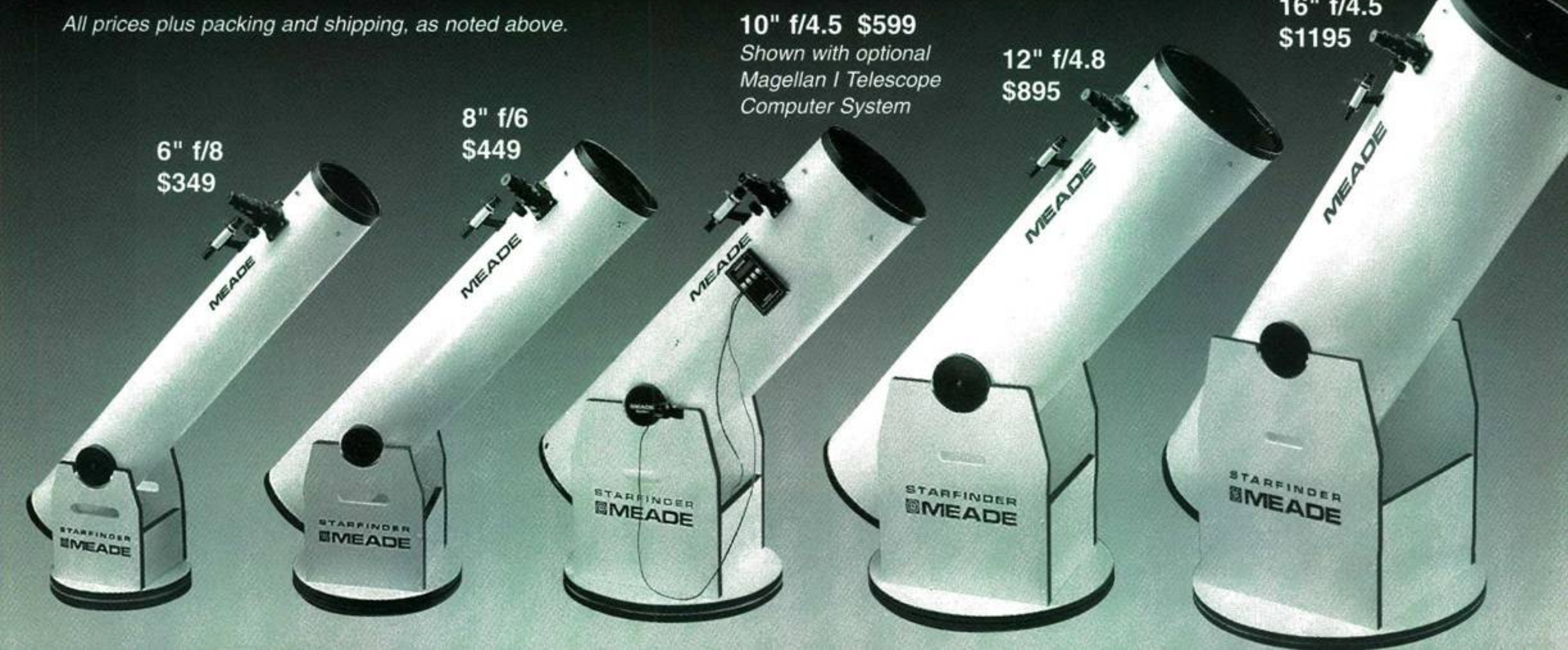
MAGELLAN I
TELESCOPE COMPUTER SYSTEM

Magellan I is supplied *complete* with control/display unit (4" x 5" x 1.25"); premium-grade, high-resolution encoders for each telescope axis (encoder precision is 5.3 arc minutes); RS-232 serial interface; bracket for placement of the controller on the telescope tube; and attachment hardware. Just add the user-supplied 9v. transistor radio battery, and Magellan I is ready to use. First-time installation is quick and simple.

#2010: for Meade Starfinder Dobsonian
6", 8", 10", 12.5", or 16" . . . . $295.
Packing & shipping in the 48 states—$15.

STARFINDER DOBSONIAN TELESCOPES ***Shown with standard-equipment 5 x 24mm viewfinder and 1.25" rack-and-pinion focuser.***

All prices plus packing and shipping, as noted above.



6" f/8
$349

8" f/6
$449

10" f/4.5 $599
Shown with optional Magellan I Telescope Computer System

12" f/4.8
$895

16" f/4.5
$1195

MEADE STARFINDER EQUATORIALS

DC-powered drive systems for fully automatic tracking, and a wide range of standard-equipment features:

Professional-Grade Optical System: Includes hand-figured, parabolic primary mirror and elliptical flat secondary, both of Grade-A Pyrex glass. Optics are multi-coated and meet the theoretical limits of resolution.

Precision Equatorial Mount: Manufactured of machined aluminum to tolerances of .001" or better, with 4"-dia. pier and die-cast tripod legs for rock-solid support of the optical tube. Moves effortlessly from object to object on precision bearing surfaces. Polar and Dec. shafts are 1" solid steel. Setting circles on both axes.

Battery-Powered Cordless Drive System! Provides fully automatic tracking of celestial objects. Operates for more than 50 hours from 6 (user-supplied) AA-size batteries. Control panel also permits powering the telescope from 12v. auto cigarette lighter plug, using optional 25 ft. cord.

2" Giant Focuser: Meade #77 2" giant rack-and-pinion focuser is included as standard equipment, with eyepiece-holders for both 2" and 1.25" eyepieces.

Accessories and Components: #637 6 x 30mm viewfinder with wide 7° field; multi-coated MA25mm eyepiece (1.25"); strong, durable, spiral-wound optical tube with attractive white finish.

Starfinder Equatorial 16: Includes equatorial mounting with 1.5" steel shafts, Sealmaster ball bearings, 6" dia. pier, and 6 x AA-size battery-powered worm gear drive; 8 x 50mm viewfinder; #77 2" giant focuser.

Packing & UPS Shipping Charges to any address in the 48 states: 6"—$65; 8"—$75; 10"—$90; 16"—$55 packing, shipped truck freight collect.

Meade Magellan Telescope Computer Systems

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TELESCOPE COMPUTER SYSTEM

Magellan I: Use the Magellan I computer to manually slew the telescope quickly to any of 12,218 database objects, or to any object of known R.A. and Dec. Specifications and object database are identical to Magellan I for Starfinder Dobsonians *(see facing page)*.

#2011: for Meade (DC-powered) Starfinder Equatorial 6", 8", or 10" . . . . $295.
#2012: for Meade (DC-powered) Starfinder Equatorial 16" . . . . 295.

MEADE
MAGELLAN II
COMPUTER - CORRECTOR
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Magellan II Computer-Corrector: Plug the Magellan II into the control panel of your Meade Starfinder Equatorial and you have all the capabilities of the Magellan I, above, including 12,218-object database, *plus* a 4-speed (2x, 8x, 16x, 32x), dual-axis, drive corrector/microslewing system.

#2018: for (DC-powered) Starfinder Equatorial 6", 8", 10" . . 495.
#2019: for (DC-powered) Starfinder Equatorial 16" . . . . 595.

Packing & shipping in the 48 states: Magellan I–$15, Magellan II–$20.

Special Eyepiece Offer! At the time you order any Meade Starfinder Equatorial telescope, you can buy 2 additional multi-coated eyepieces, MA9mm and 12mm, ***for a total of $29.95!*** *Purchased separately, the 2 eyepieces sell for $75.90.*

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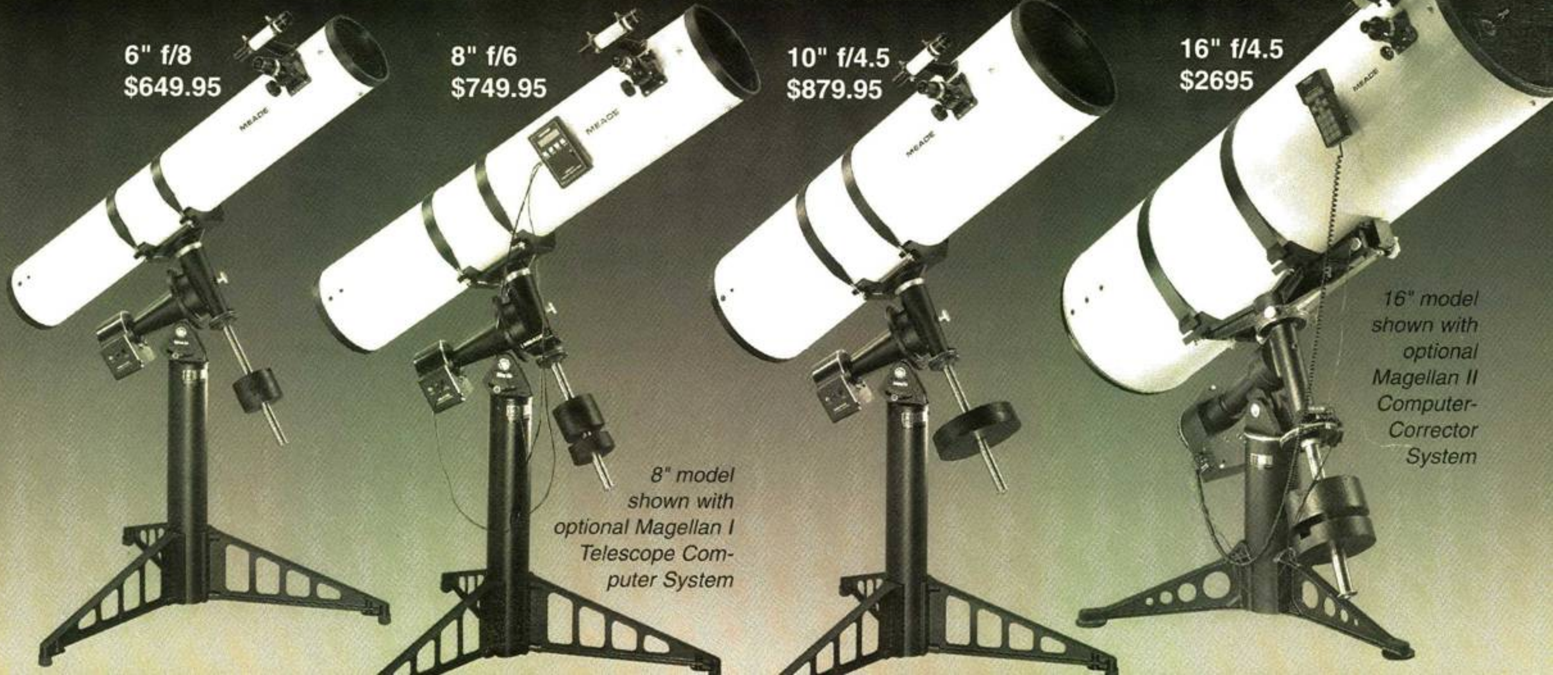
STARFINDER EQUATORIAL TELESCOPES ***Shown with standard-equipment 6 x 30mm or 8 x 50mm viewfinder and 2" giant focuser.***



8" model shown with optional Magellan I Telescope Computer System

16" model shown with optional Magellan II Computer-Corrector System

MEADE 8" LX10

MEADE LX10 EMC
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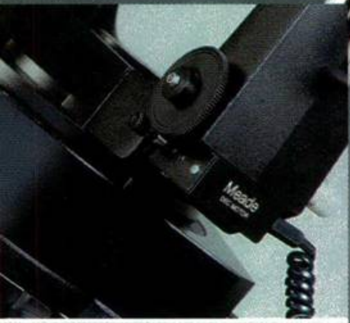

Add the optional LX10 Declination Motor for dual-axis corrections at 2x.

Meade 8" LX10
Schmidt-Cassegrain Telescope, shown with standard-equipment equatorial wedge and hand controller and with optional LX10 Field Tripod.

All the optical performance of Meade 8" LX50 and LX200 Schmidt Cassegrains...for only *$995!*

For the serious amateur astronomer on a more limited budget, or for the more casual observer who nonetheless demands the very finest in optical performance, the Meade 8" LX10 satisfies every requirement. *No other similarly-priced 8" Schmidt-Cassegrain offers such a range of standard features* — or such a range of important options for special applications. *Standard-equipment includes:*

Super Multi-Coated Optical System: The LX10 includes the *exact same* 8" Schmidt-Cassegrain optical tube assembly as more expensive Meade 8" LX50 and LX200 models. Super multi-coatings (not available even as an *option* on competing 8" telescopes) are included with every LX10 optical system, for the highest levels of light transmission and image contrast.

Equatorial Fork Mounting: The relatively light weight, but very stable, LX10 fork mounting provides all of the rigidity required for sensitive high-power applications of the telescope, or for photographic or CCD imaging. Ball bearings on the polar axis complement the precise action of the internal worm gear system.

Cordless, DC-Powered Electronic Motor Drive: A drive system that includes an electronically-regulated DC servo motor for automatic *sidereal-rate* tracking. The drive is powered by four AA-size batteries that fit conveniently through the telescope's control panel; battery life is in excess of 50 hours.

Worm-Gear System: The LX10's 5.75"-diameter worm gear produces extremely smooth, regular motion in R.A., with low periodic error — a periodic error that permits such advanced capabilities as long-exposure astrophotography or CCD imaging.

Hand Controller: Essential for micro-guiding the telescope during long-exposure astrophotography, the LX10's pushbutton hand controller enables precise corrections in R.A. at 2x speed. With the optional electric Declination motor added to the telescope, the hand controller is functional at 2x speeds on both telescope axes. Both the standard-equipment hand controller and the optional electric Declination motor plug into the telescope's control panel.

SPECIFICATIONS: 8" Model LX10 — Includes 8" Schmidt-Cassegrain optical tube assembly with EMC super multi-coatings (D = 203mm; F = 2000mm, f/10); fork mount with setting circles, manual slow-motion controls, and locks on both axes; 5.75" LX worm gear reduction system; sidereal-rate electronically-regulated DC servo motor drive; 4-pushbutton hand controller for 2x speed corrections in R.A.; battery compartment accepting four (user-supplied) AA-size batteries (telescope may also be powered from an auto cigarette lighter plug, using optional 25 ft. cord); 6 x 30mm viewfinder; eyepiece-holder and diagonal prism (1.25"); MA25mm multi-coated eyepiece; standard equatorial wedge with elevation scale, fine elevation control, and 360° azimuth orientation capability; complete operating instructions.
$995. (+ $65 packing & shipping in the 48 states)

LX10 Field Tripod	**195.**
LX10 Electric Declination Motor System	**85.**
#2014 Magellan I Telescope Computer System for LX10, with 12,218-object database	**375.**

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EYEPIECES AND ACCESSORIES

Series 4000™ Super Plössls 52° field; multi-coated

Meade 4-element Super Plössls, updated and redesigned to utilize the latest in optical glass-types, are the finest general-purpose eyepieces available. For observing hairline lunar and planetary detail, splitting close doubles, or for deep-space; guaranteed to deliver more contrast and image sharpness than any other brand. Rubber eyeguards fold down for eyeglass wearers–a feature not available on competing brands. Multi-coated. All focal lengths through 32mm are parfocal.

Super Plössls (SP; 4-elements; 1.25"; 52°):

6.4, 9.7, 12.4, 15, 20, 26mm	each:	**$79.95** (3.45)
32mm (52°); **40mm** (44°)	each:	**99.95** (3.79)
56mm (52°; 2")		**199.95** (5.48)

Series 4000™ Ultra Wide Angle 84° field; multi-coated

The ultimate eyepieces; extreme image sharpness over an amazing 84° field. A perfect optical match with Schmidt-Cassegrains and fast Newtonians.

Ultra Wide Angle (UWA; 8-elements; 1.25"; 84°)– **4.7mm: $169.95** (3.94); **6.7mm: 199.95** (3.94); **8.8mm** (1.25"/2"): **239.95** (5.87); **14mm** (1.25"/2"): **299.95** (6.28)

Series 4000™ f/6.3 Focal Reducer/ Field Flattener

f/6.3 FOCAL REDUCER/FIELD F

Manufactured to exclusive Meade optical designs; threads on to any Meade or Celestron Schmidt-Cassegrain rear cell and converts f/10 scopes to f/6.3 (or f/6.3 SCT's to f/4), while significantly flattening the field. Use with SCT visual or photo accessories. Actual visual field is increased by 56%, for fine wide-field views of star fields and nebulae. In astrophotography, reduces exposure times by about 50%, while producing an actual field diameter of 1.5" at the film plane. A tremendous aid with CCD imagers in reducing image size for locating and centering images on CCD chips. 4-element optics; multi-coated; 41mm clear aperture.

$129.95 (3.60)

2x Telenegative Barlow (1.25")

#122: Doubles eyepiece power with sharp, high-resolution, high-contrast imaging on telescopes of all types. 27mm dia. (26mm clear aperture). Excellent corrections for chromatic and spherical aberrations at all photo-visual wavelengths. Multi-coated. 1.25"

$47.95 (3.45)

2x Short-Focus Barlow (1.25")

#126: Only 2.5" long, the #126 works well with any telescope accepting 1.25" eyepieces, even those with limited focus range. Maintains the high image quality of the #122, above. Insert the #126 into star diagonal for 2x or insert star diagonal into #126 for 3x. 26mm clear aperture. Multi-coated.

$47.95 (3.45)

2x-3x Variable Barlow (1.25")

#127: Precision internal sliding lens assembly permits continuously variable power settings between 2x and 3x. Engraved scale indicates power in use. Yields bright, sharp, high-contrast images on telescopes of all types. Multi-coated; 1.25".

$59.95 (3.45)

2" Diagonal Mirror

#929: Permits use of wide-field 2" oculars. Threads on to rear cell of Meade and Celestron SCT's. Includes multi-coated precision optical flat made at the Meade factory; with 1.25" eyepiece adapter. **#930:** Same as #929 but with 2" barrel to fit into focusers with 2" eyepiece-holders.

#929 or **#930,** each: **$99.95** (5.87)

45° Erecting Prisms

Fully coated roof prisms to invert the astronomical image in Schmidt-Cassegrains or refractors during terrestrial observations, while presenting a convenient 45° observing angle. Specify **#927** (.965"), **#928** (1.25"), or **#931** (fits .965" focuser, accepts 1.25" eyepieces).

$42.95 (3.45)

World's Most Advanced Illuminated Reticle Eyepiece

Series 4000 Plössl 9mm, with rubber eyecup and micrometric X-Y positioning of the reticle within the field. Greatly facilitates locking on the guide star. Sharp high-power imaging, excellent eye relief. Wireless red LED illuminator with adjustable brightness control. Multi-coated optics. **Internal batteries included.** Bullseye reticle. 1.25".

$149.95 (3.45)

Series 4000 Plössl 9mm—Same as above but with 6 ft. cord and plug for Meade LX3, LX5, LX6, LX100, LX200, and APO power panels, in place of wireless illuminator.

$129.95 (3.45)

Series 4000 Photo-Visual Color Filters (1.25")–Premium filters, made of purest crown optical glass, dyed in the mass. For increased contrast and resolution on the Moon and planets. Thread into the barrels of virtually all 1.25" eyepieces sold today. Fully coated.

#8 Lt. Yellow; #11 Yellow Green; #12 Yellow; #21 Orange; #23A Lt. Red; #25A Red; #38A Dark Blue; #47 Violet; #56 Lt. Green; #58 Green; #80A Blue; #82A Lt. Blue	each **$14.95** (2.29)
Set #1–4 filters: #12, #23A, #58, #80A	**49.95** (2.98)
Set #2–4 filters: #11, #25A, #47, #82A	**49.95** (2.98)
Set #3–4 filters: #8, #21, #38A, #56	**49.95** (2.98)

Series 4000 Moon Filter (#ND96): Reduces glare and irradiation during lunar observing. 13% uniform light transmission across the visual spectrum. Threads into 1.25" barrels. **$16.95** (2.29)

#905 Variable Polarizer (1.25")

For glare reduction in observing the Moon. Includes two Polarizer filters mounted in a machined cell and permits continuously variable light transmission from 5% to 25%, to compensate for varying lunar surface brightness according to the Moon's phase and the aperture of the telescope. Accepts 1.25" eyepieces. **$49.95** (4.27)

Modified Achromatic Eyepieces

Meade 3-element MA eyepieces yield sharp, well-corrected images on the Moon, planets, and deep-space at a reasonable price. Multi-coated; threaded for filters; 1.25" barrel diameter. Apparent field: 40°. **MA 9, 12, 25, 40mm.**

each: **$37.95** (3.45)

MA12mm Illuminated Reticle Eyepiece

Excellent 3-element optical system, long eye relief, fully coated, with double crossline reticle. Wireless red LED illuminator and variable brightness control. 1.25" **Batteries included.** **$99.95** (3.45)

As above but with 6 ft. cord and plug for Meade telescopes with power panels, in place of wireless illuminator. **$79.95** (3.45)

Camera Adapters

Professional-quality adapters for rigid coupling of telescope-to-camera. Use for either Eyepiece-Projection or Prime Focus. Precision-machined of aluminum and brass, threaded for filters. Use with T-mount, available separately.

.965": **$27.95**; 1.25": **$29.95** (2.98)

Variable Tele-Extender

For eyepiece-projection photography with any Meade or Celestron SCT. Threads on to eyepiece-holder. Sliding cell with lock permits wide range of projection magnifications with the same eyepiece. Use with T-mount for your camera.

$39.95 (2.98)

Variable-Projection Camera Adapter (1.25")

Machined sliding cell allows variable projection power in eyepiece-projection photography; permits precise selection of correct photo power in lunar and planetary photography; threaded for filters. Use with T-mount for your camera.

$39.95 (2.98)

T-Adapters for SCT's

Rigidly couples camera to telescope for prime focus photography with any Meade or Celestron Schmidt-Cassegrain. Use with T-Mount for your 35mm camera.

$26.95 (2.98)

Series 4000™ 2x Apochromatic Barlow Lens

#140: The most advanced Barlow lens available for commercial telescopes, the Meade #140 includes 3-element, multi-coated, air-spaced optics. Doubles the power of any eyepiece with which it is used and yields images absolutely unmatched in resolution, contrast and color correction. The #140 optically complements any telescope — refractor, reflector, or Schmidt-Cassegrain. Accepts 1.25" eyepieces. Mechanical components are of machined aluminum and brass. Lens diameter is 28mm; clear aperture 26mm.

$79.95 (4.27)

Series 4000™ Super Wide Angle 67° field; multi-coated

For exquisite wide-angle images at low-to-medium powers, with pinpoint edge-of-field resolution. Ideal for star fields, galaxies, and other deep-space phenomena. SWA 13.8mm, 18mm, and 24.5mm are superb complements to the #140 Barlow, above.

Super Wide Angle (SWA; 6-elements; 1.25"; 67°)–**13.8mm: $139.95** (3.94); **18mm: 149.95** (3.94); **24.5mm: 179.95** (4.68); **32mm** (2"): **239.95** (5.87); **40mm** (2"): **299.95** (6.28)

Series 3000™ Plössls 50° field; multi-coated

Meade Series 3000 Plössls yield the finest image corrections obtainable from the classical 4-element Plössl design. Available in a wide range of focal lengths from 5mm through 25mm. All five eyepieces are parfocal, so that, at most, only slight refocusing of the image is necessary from eyepiece to eyepiece. Unlike competing moderately-priced Plössls, Meade Series 3000's are **multi-coated** for maximum light transmission and image contrast. Chrome-plated brass barrels are threaded for standard filters; each eyepiece includes a fold-down rubber eyeguard for comfortable observing. Made exclusively for Meade Instruments by one of Japan's leading lensmakers, Series 3000 Plössls produce fine, high-resolution results on reflectors, refractors, and Schmidt-Cassegrains of any focal ratio.

Series 3000 Plössls (4-elements; 1.25"; 50°)
5, 6.7, 9.5, 16, 25mm each: **$49.95** (3.45)

#911B
#910B
#908B

#911N
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Series 4000 Nebular Filters—Premium multi-layer interference filters, the finest obtainable. Use broadband ("B") filters to block most forms of light pollution; use narrowband ("N") filters in heavily light-polluted areas or for extremely high-contrast observing of faint nebulae.

#908B–Threads into 1.25" eyepieces, 26mm dia.	**79.95** (3.45)
#910B–Threads into 2" eyepieces, 44mm dia.	**119.95** (3.85)
#911B–Threads on to rear cell of Schmidt-Cassegrain telescopes. 36mm dia.	**99.95** (3.94)
#908N–Threads into 1.25" eyepieces, 26mm dia.	**89.95** (3.45)
#910N–Threads into 2" eyepieces, 44mm dia.	**129.95** (3.85)
#911N–Threads on to rear cell of Schmidt-Cassegrain telescopes. 36mm dia.	**119.95** (3.94)

Series 3000™ Plössl 40mm 44°

An excellent complement to the Series 3000 Plössls above, this all-new Plössl 40mm produces spectacular low-power, wide-field results with any telescope. Includes classical 4-element Plössl optics, **multi-coated.** Barrel dia. 1.25"; threaded for filters; rubber eyeguard. Apparent field: 44°.

$79.95 (3.79)

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Prices shown are suggested U.S.A. mail-order retail prices and do not include any applicable sales taxes. Suggested shipping and handling charges to the 48 states by U.P.S. or U.S. Mail shown in ( ) next to each price. **The following national mail-order dealers carry all Meade accessories in-stock for immediate shipment:**

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Raising Young Astronomers

Highest regards to Steve Olson on his article "Raising Astronomers" (December 1997). I am presently teaching astronomy in my daughter's class on a volunteer basis. Though I can only get there twice a month, the children love learning about the night sky when I come. I began last year with the appearance of Comet Hale-Bopp, and the project has skyrocketed. I supplement my presentation with a handout outlining what I've discussed so the children can share what they learned in class with their families, and I've been approached by several parents who wanted to tell me how much their children have enjoyed the experience.

I will never forget my daughter's reaction to seeing a meteor for the first time — or the first time she identified Orion and the Big Dipper in the night sky. We as parents who enjoy the wonders of the universe can play a huge part in securing astronomy for our children to enjoy. — *Ernest Favulli, Shrewsbury, Massachusetts*

It was a pleasure to read the editorial in the December 1997 issue of *Astronomy* ("Making the Sky Clear"). This is a topic close to my heart and one that I agree needs more emphasis.

For the past six months I have been the Youth Education Coordinator for the New Jersey Astronomical Association — a learning experience, both good and bad. I've had my share of kids asking about aliens, noticing blemishes in photographic slides, and giggling about cloaking devices. At the same time, I have been surprised as ten and 12 year olds ask questions about NEOs, multiple star systems, extrasolar planets, and cosmological matters.

As amateur (and, in many cases, professional) astronomers, we need to make certain that the next generation has an appreciation for the night sky. Holding youth events at a local astronomical association and scheduling talks through local elementary schools are two easy and effective ways to expose our science to the people who, in decades to come, will take up the torch of astronomy and carry it through the next series of discoveries. If we fail at this, the time may come when, as editor Bonnie Gordon wrote, the public will know as little about the night sky as did those living in the Middle Ages. Let's all try to make sure this doesn't happen. — *Bill Knispel, Pittstown, New Jersey*

We very much enjoyed and appreciated Steve Olson's article on "Raising Astronomers" in your November issue. It would certainly be wonderful if more amateur astronomers got personally involved in our country's educational system. While the article very kindly mentioned Project ASTRO, which is devoted to helping astronomers do this, it neglected to give our address for those who want more information about our program and materials. We can be contacted at: Project ASTRO Information, Astronomical Society of the Pacific, 390 Ashton Avenue, San Francisco, CA 64112 or by fax at (415) 337-5205. — *Andrew Fraknoi, Director, Project ASTRO*

Thank you for the story "Raising Astronomers" and the editorial "Making the Skies Clear" in the December 1997 issue. As a long-time subscriber to *Astronomy*, I applaud your call to "find and nurture young astronomers."

It seems strange to me that with so much public attention being drawn to space exploration, astronomical phenomena, and questions of cosmology, there is not more attention given to basic astronomy in many schools.

As an amateur astronomer I have found a wonderful means of sharing my enthusiasm for astronomy by teaching short courses in the gifted and talented school program for grades four through six in upstate New York. There is an abundant interest on the part of the students. These bright kids can choose from a menu of about 20 courses, and though some are cancelled for lack of interest, the astronomy course is always filled. — *Richard Rieger, Gansevoort, New York*

The Tragedy of Robert Burnham Jr.

Like many others, I'd always thought that Robert Burnham Jr., author of *Burnham's Celestial Handbook*, was the same Robert Burnham of *Astronomy* magazine. In fact, I wrote the latter a few years ago encouraging an update of the handbook series. Your Robert Burnham kindly wrote back to me and let me in on the odd coincidences of his name often erroneously being connected with the publication. But nothing was then known about the Burnham of the books.

Your story on Robert Burnham Jr. was well done and tastefully so, though tragic in its ending. It is really a shame that Robert Burnham couldn't find a position at any of the Arizona universities — with their specialization in astronomy — at least helping out on the graduate level. I suppose that his educational credentials were not such that even a high school teaching position could have been realized, but his expertise should have been enough to override his lack of certification. He could have been a wonderful technical assistant to any astronomy department head and could have commanded a salary that would have given him a better, and well deserved, lifestyle. Probably now somewhere in the United States there are astronomy department heads shaking — after reading your story — because they didn't know of this man's plight or want. Burnham could have helped many serious astronomy students develop their skills earlier and faster. I'll bet that most of today's top professionals at one time or another lifted the leaves of *Burnham's Celestial Handbook* in awe and wonder

(cont. on p. 21)

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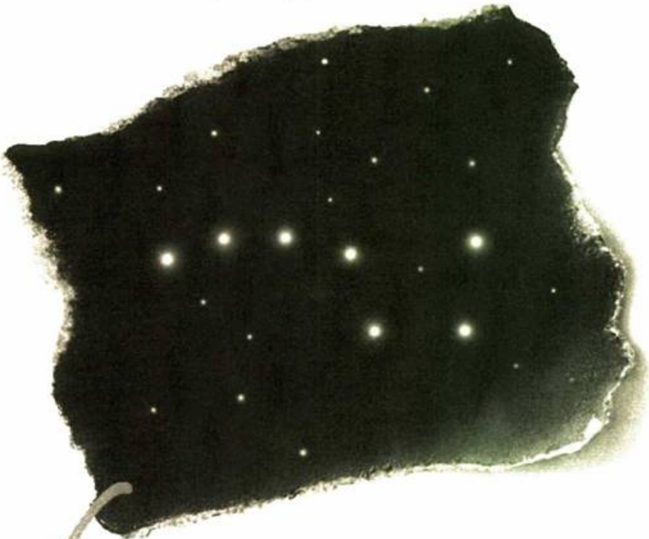

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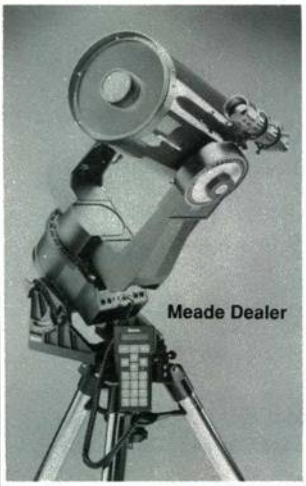

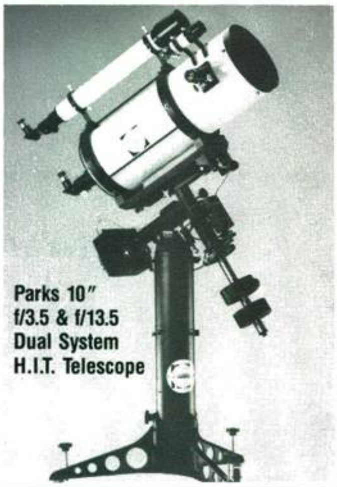

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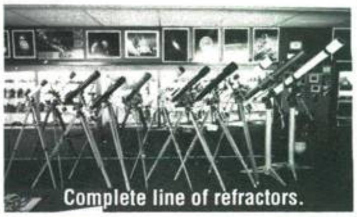

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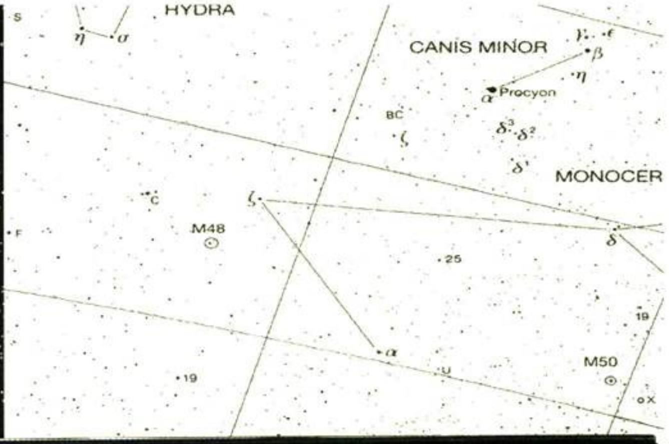

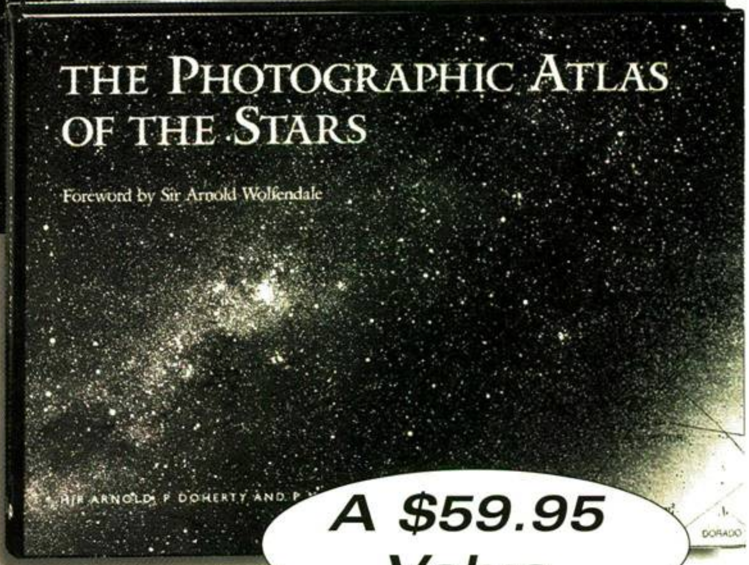
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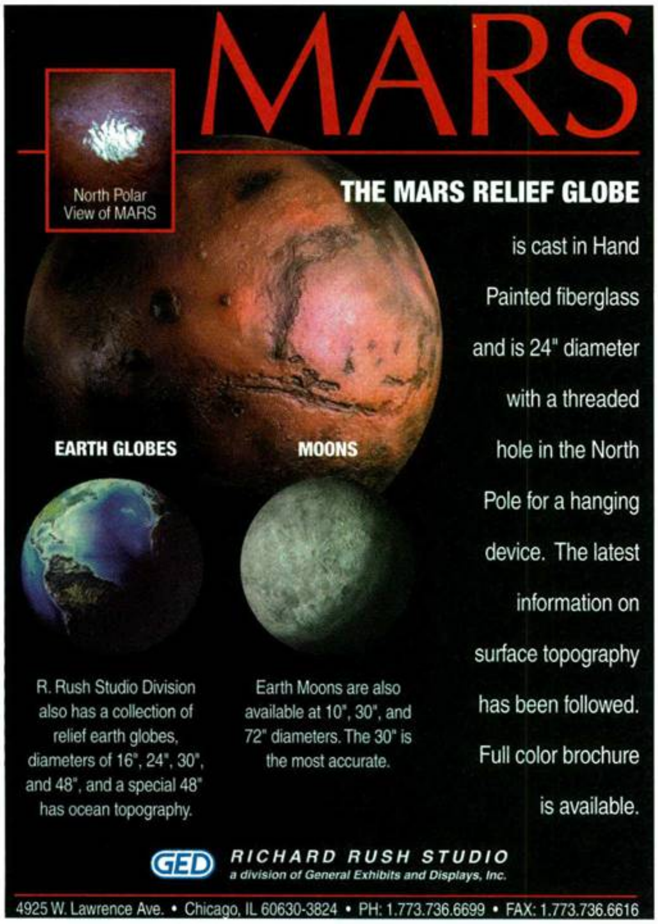

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of the voluminous work therein. We owe him a great debt but are left now only to offer up a simple prayer. Thank you Robert Burnham Jr. May God give you clear skies forever. — *Ken Discorfano, Tucson, Arizona*

The article on Robert Burnham, Jr. struck a very sensitive chord in my heart. I am sorrowed to hear of his passing and the tragedy of his last years. I have used and enjoyed his *Celestial Handbook* for 17 years. Having literally worn out the softcover version, I purchased the hardcover edition recently.

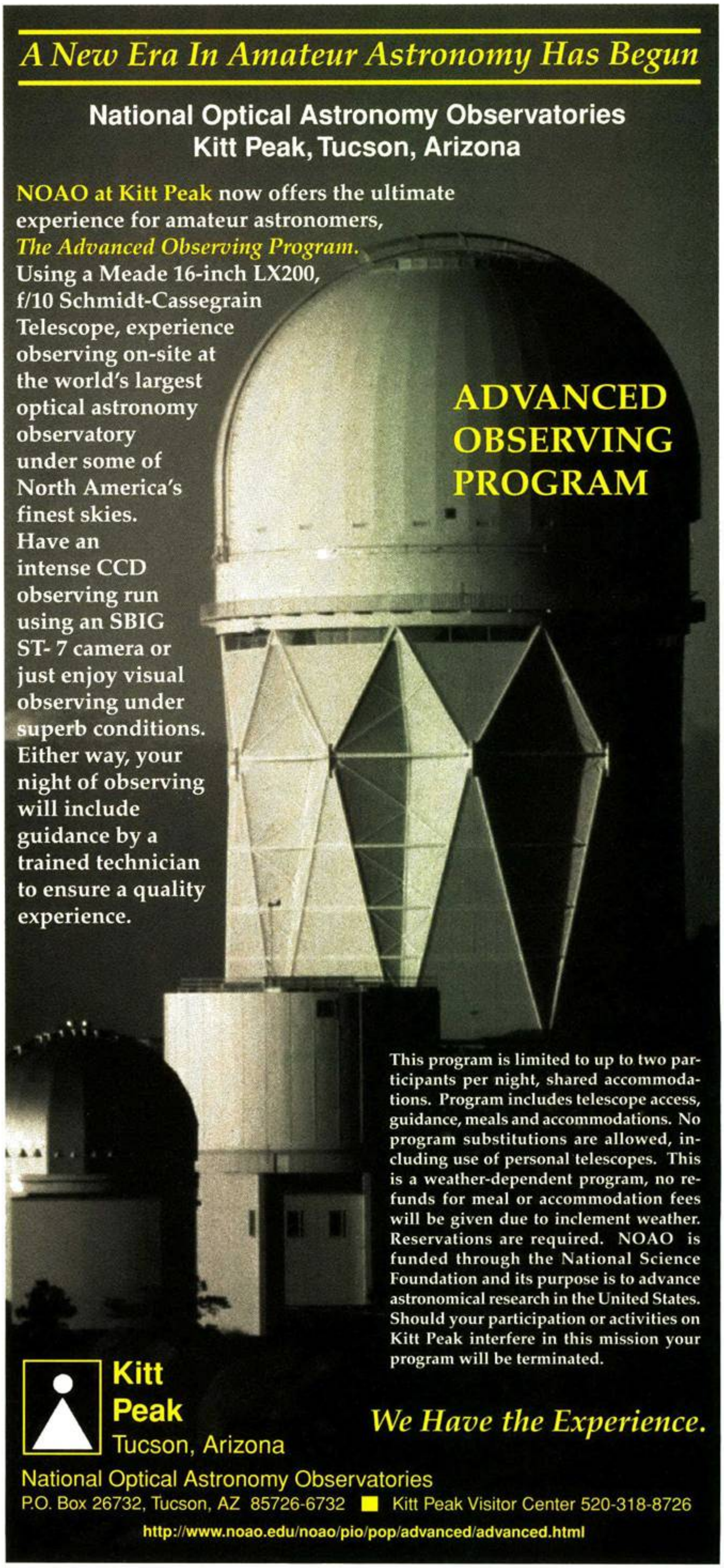
It is amazing that the combination of mythology, quotations from classical literature, photography, coin history, drawings, orbit data, field charts, astronomical facts, and observational data could have been so well compiled by a single, self-educated person prior to the age of computers. — *Donald K. Judd, Midland, Texas*

Monks and Astronomers Tango

Astronomy magazine is wonderful! It's good to read the historical articles every now and then, like the one in the December issue entitled "Vulcan Chasers." The historical bent provides a lucid perspective on how much astronomers of the past did not know and how much more we know and hope to know.

Being a Trappist monk, I was amazed to find the word "Trappist" used twice in a recent article. In the same December issue you ran an article on Allan Sandage entitled "Astronomy's Feisty Old Man," in which he was likened to a monk. We at Mepkin Abbey rise at 3 a.m., a few of us even earlier. Monks have a particular fascination with the heavens and its denizens. So, the article led me to think that astronomer-like monks can make excellent monk-like astronomers! — *Robert Wojciechowski, Moncks Corner, South Carolina*

Astronomy invites you to talk back. Send letters to Astronomy Talking Back, P.O. Box 1612, Waukesha, WI 53187; e-mail to talking@astronomy.com. Letters may be edited for space or clarity.



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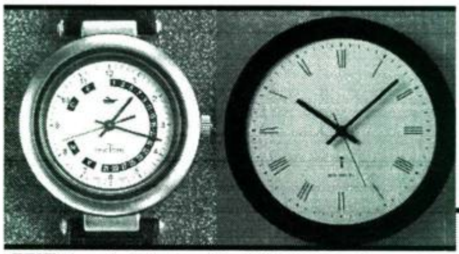

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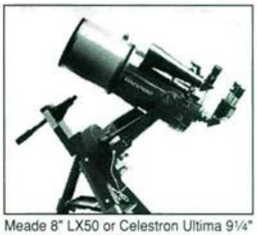
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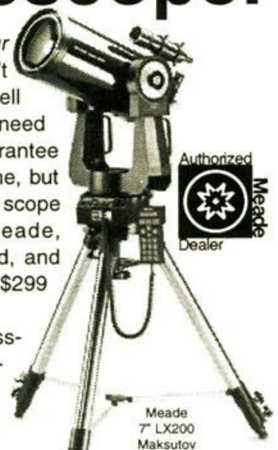
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SUPERLUMINAL MOTION

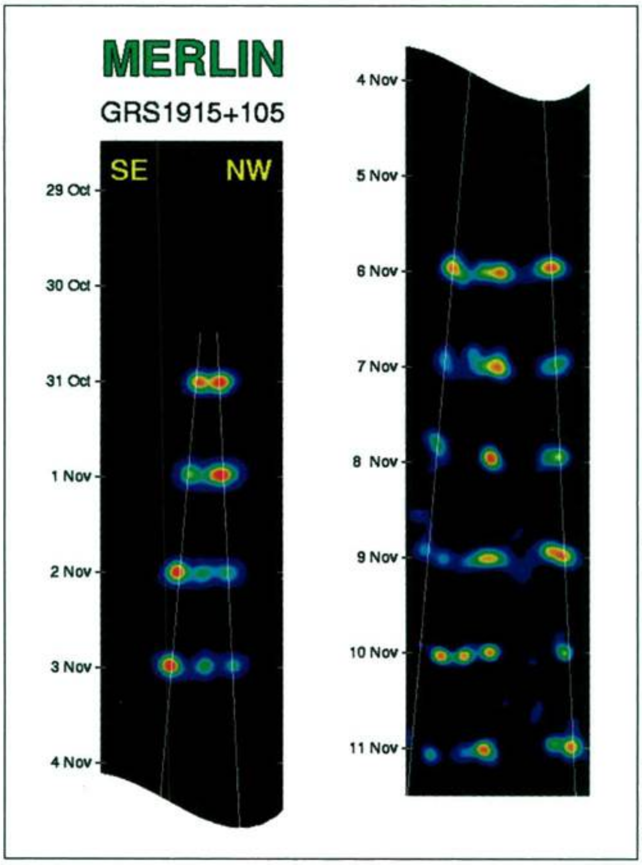
A Black Hole Erupts

A faster-than-light source in our galaxy

► The MERLIN radio telescope array in England has just provided the highest resolution view of material zooming away from a black hole. A series of images acquired over a two-week period in October and November 1997 show blobs of gas ripping through space at more than 90 percent the speed of light. Because one of the blobs is traveling toward us, it *appears* to be moving at more than twice the speed of light. This superluminal motion is just an optical illusion resulting from our viewing angle (see Ask Astro, page 94).

The source, known as GRS 1915+105, is roughly 40,000 light-years away on the other side of the galaxy. It consists of a black hole weighing in with at least three solar masses and an orbiting companion star. Gas from the star's wind falls into the powerful gravitational clutch of the black hole. Intense magnetic fields surrounding the black hole funnel some of this gas into twin jets that shoot away from the black hole in opposite directions. The details of how this happens, and why GRS 1915+105 undergoes sporadic outbursts, remain a mystery.

MERLIN consists of six individual radio telescopes spread across England. By combining the signal from each scope, astronomers achieve the resolving power of a single radio telescope 217 km wide (135 miles).



The MERLIN radio telescope array shows a time-lapse movie of blobs of hot gas shooting in opposite directions from the black hole in GRS 1915+105. MERLIN tracked the motion of the blobs for two weeks until their radio emission was too faint to be detected.

Nuffield Radio Astronomy Laboratories/University of Manchester

MERLIN's resolution of 40 milliarcseconds (the size of a penny seen at 50 miles) was five times better than observations of GRS 1915+105's previous eruption seen in 1994. "We were able to resolve much finer structure, we can see details of jets bending, we can investigate the acceleration and deceleration of the jet. We should come away knowing much more about the formation of jets from black holes," says Robert Fender of the University of Amsterdam in the Netherlands.

Most superluminal jets are observed emanating from quasars, which are billions of light-years away.

GRS 1915+105 is one of only two superluminal sources known in our galaxy. Because it is much less energetic than a quasar, GRS 1915+105 is often referred to as a microquasar, and studies of it should shed light on its more powerful cousins. It was discovered in 1992 by the Russian x-ray satellite Granat.

LIFE ON MARS

No Martian Microfossils?

► Ever since NASA and Stanford University researchers announced evidence for life in the martian meteorite known as ALH84001, skeptical scientists have acted like hungry lions ready to pounce on their prey.

In the December 4, 1997, issue of *Nature*, three prominent skeptics question one of the key pieces of evidence supporting the life interpretation: the microscopic worm-shaped structures that the NASA/Stanford team interpreted as being possible martian microfossils. The skeptics, Ralph Harvey of Case Western Reserve University, Hap McSween of the University of Tennessee, and John Bradley of the Georgia Institute of Technology, argue that these tiny structures were most likely formed by run-of-the-mill geological processes rather than by biological processes.

Harvey, McSween, and Bradley claim to show that the worm-shaped structures are nothing more than lamellae, fractured surfaces of mineral crystals. They go on to say that when the worm-shaped objects are viewed from a certain angle under a high-powered microscope, they are clearly attached to and are part of the mineral surfaces. Lunar rocks, they note, contain similar structures, and nobody thinks those are of biological origin.

"We haven't driven the final nail in the coffin yet

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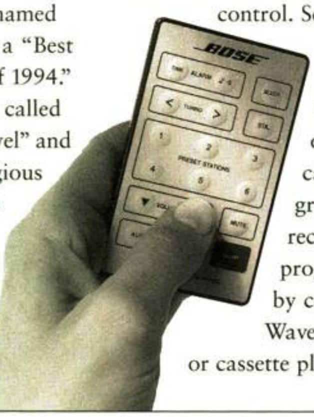

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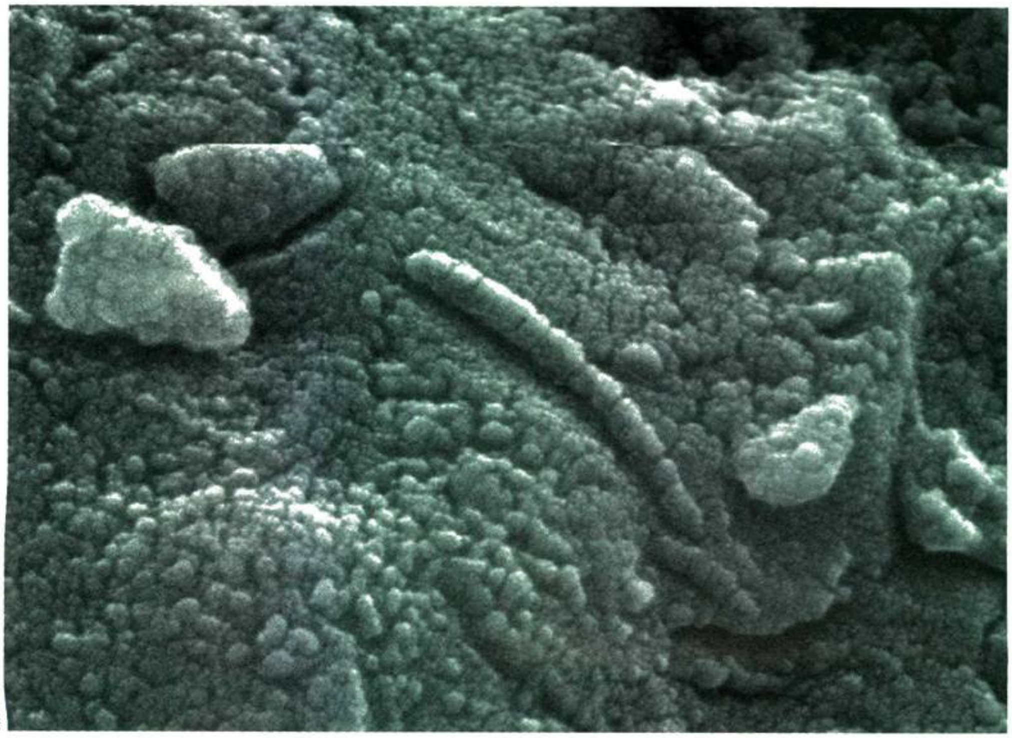
about organisms in this martian rock," says Harvey. "But our latest article offers a lot of insight that shows these fracture zones in the rock are incredibly complex and that it is dangerous to try to draw any hypothesis from a few pictures."

Everett Gibson of NASA's Johnson Space Center, a member of the NASA/Stanford team, says Harvey's team was looking at a different part of the rock and seeing different kinds of worm-shaped structures than the ones the NASA team observed. "We're talking about differences between apples and oranges. It's an example of the complexity of this rock. You really need to know where you are in the rock and what you are studying," counters Gibson, who also noted that the Harvey team has attacked only one of several independent lines of evidence supporting the hypothesis that past life exists in ALH84001.

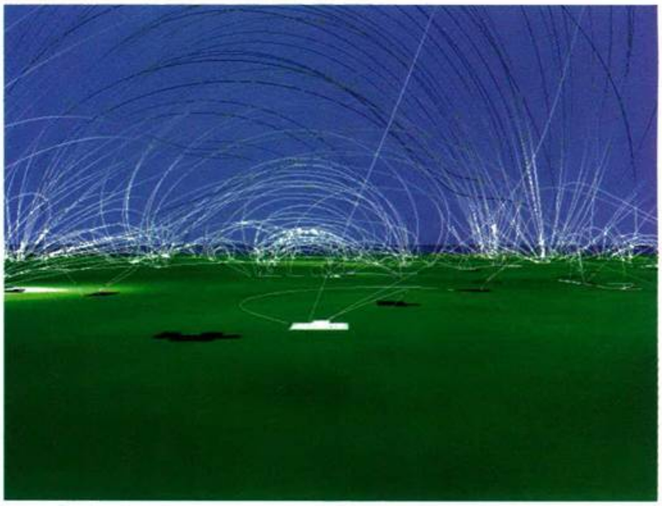
NASA team leader David McKay adds, "The elongated features that we suggest might be microfossils are much larger than the lamellae, and are not very similar to the features identified by the Harvey group."

In any case, it appears the ultimate answer to whether life once existed on Mars won't be known until we bring back more samples from Mars.



NASA scientists interpret this worm-shaped structure — which is 1/100 the width of a human hair — as a possible martian microfossil, an interpretation that some other scientists dispute.

NASA/Johnson Space Center



This computer-generated sunscape represents the tens of thousands of magnetic field lines dubbed the sun's magnetic carpet. They emerge continuously, extend upward, and, in the process, carry huge amounts of energy into the solar corona. Solar and Heliospheric Observatory

The wispy, high-speed solar corona extended millions of miles during the 1988 total solar eclipse. High Altitude Observatory/National Center for Atmospheric Research)

SOLAR PHYSICS

Magnetic Carpet May Heat Sun's Corona

▶ For more than half a century, astronomers have pondered how the sun's outer atmosphere, or corona, can be so hot. While the temperature at the surface of the sun (the photosphere) registers a balmy 6000° C (11,000° F), the corona blazes away at more than a million degrees.

New observations from the joint NASA and European Space Agency's Solar and Heliospheric Observatory (SOHO) suggest that magnetic energy heats the corona. Alan Title, a solar physicist at the Stanford-Lockheed Institute for Space Research and leader of the research team, says "We now have direct evidence for the upward transfer of magnetic energy from the sun's surface toward the corona."

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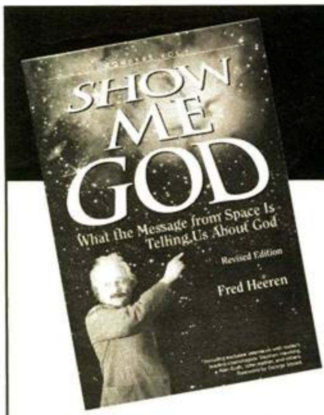

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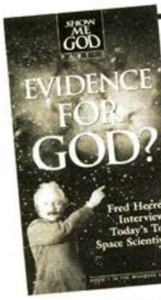

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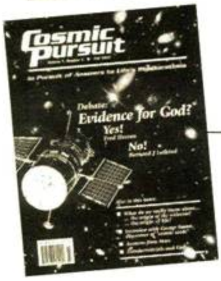

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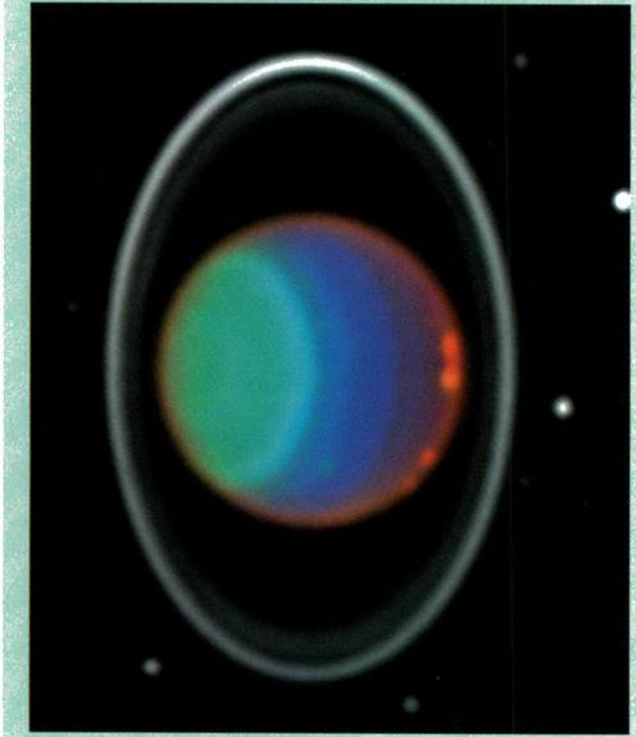
The sun is covered everywhere with magnetic field lines that look like the loops of a carpet. On average, each of the roughly 4,000 loops that emerge daily from this "magnetic carpet" produces as much energy as the United States uses in 100 years. "The way the magnetic field releases its energy is through big current sheets that essentially short circuit," says Title. "There is more than enough energy to heat the corona to its known temperature."

In related news, solar physicists Richard Woo of the Jet Propulsion Laboratory and Shadia Habbal of the Harvard-Smithsonian Center for Astrophysics led a research team that may have found how the sun's powerful magnetic fields can accelerate to supersonic speeds the solar wind — a stream of charged particles that flows from the sun.

Woo and Habbal looked for the sources of the wind's two components: a steady, fast wind that blows at up to 800 kilometers per second (500 miles per second) and a slower (600 kilometers per second), more unpredictable wind. Using observations from interplanetary spacecraft, such as Ulysses and the Jupiter-orbiting Galileo, that occasionally move behind the sun so that their radio signals pass through the gas near the sun's surface, Woo and Habbal found that the slow wind likely emanates from raylike structures of solar plasma called stalks. They then used SOHO as a type of police radar gun to confirm that the stalks were the source of the slow wind.

The origin of the fast wind remains controversial. Solar physicists had thought this wind flows from coronal holes near the sun's poles. But Woo and Habbal found that the wind arises all over the sun. According to them, whether a slow or fast wind comes from the sun depends only on differences in the local magnetic field. If this idea holds up (and there are a lot of skeptics out there), it will mark a major change in solar physics.

HUBBLE SPACE TELESCOPE



Erich Karkoschka (Univ. of Arizona) and NASA

NOT SO BLAND AFTER ALL, blue-green Uranus shows cloud bands similar to those seen on Saturn and Jupiter in this false-color Hubble image from July 28, 1997. Taken with the recently installed Near Infrared Camera and Multi-Object Spectrometer, this three-image composite uncovers structure never before seen in the uranian atmosphere. Each color represents a different wavelength and therefore a different cloud layer. Blue indicates clear skies and the deepest layers of the atmosphere. Green is sensitive to methane absorption and represents mid-levels of the atmosphere, while red indicates hydrogen absorption and features at high altitudes. Both green and red represent hazy conditions. Five high-altitude, bright red-orange clouds can be seen near the right limb of the planet, while a deeper green cloud can be found near the center bottom of the image.

Although the planet's rings and moons are faint at visible wavelengths, they shine brightly in the near infrared. The brightest ring seen here is the Epsilon ring, while the brightest moon (upper right) is Puck.

GENERAL RELATIVITY

Einstein Confirmed

▶ Black holes, gravitational waves, warped space-time — all these seemingly bizarre effects were predictions based on Albert Einstein's general theory of relativity and later confirmed by observations. Now two teams of astronomers have found evidence to support yet another exotic Einsteinian prediction called frame dragging, in which a object literally drags space and time around itself as it rotates.

Using NASA's Rossi X-ray Timing Explorer (RXTE) spacecraft, the two teams measured the periodic brightness variations in x rays emitted by the hot gas in orbit around several neutron stars and suspected black holes. These objects all belong to binary systems in which the intense gravity of the neutron star or black hole pulls gaseous material from its companion. This gas forms an accretion disk around the collapsed object, and friction in the disk heats the material to such a high temperature that it emits x rays.

If the disk happens to lie at an angle to the equatorial plane of the neutron star or black hole, however, relativity predicts that the disk should wobble like a spinning top as it gets caught up in the space-time being dragged around by the collapsed object. The wobble reveals itself as a periodic change in the x-ray brightness.

The first research team, led by Wei Cui of the Massachusetts Institute of Technology, studied the x-ray emission from five black-hole candidates. The astronomers found that the faster the emission varied — indicating

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greater frame dragging — the faster the black hole rotated, just as relativity predicts.

The second group of researchers, headed by Luigi Stella of the Astronomical Observatory of Rome, found a similar effect in RXTE observations of 15 neutron stars. Both teams announced their results at the November 1997 meeting of the American Astronomical Society's High Energy Astrophysics Division.

"If our interpretation is correct, it could demonstrate the presence of frame dragging near spinning black holes," said Cui. As such, it would be a momentous discovery, and another triumph for Einstein's grand theory.

CLUSTER EVOLUTION

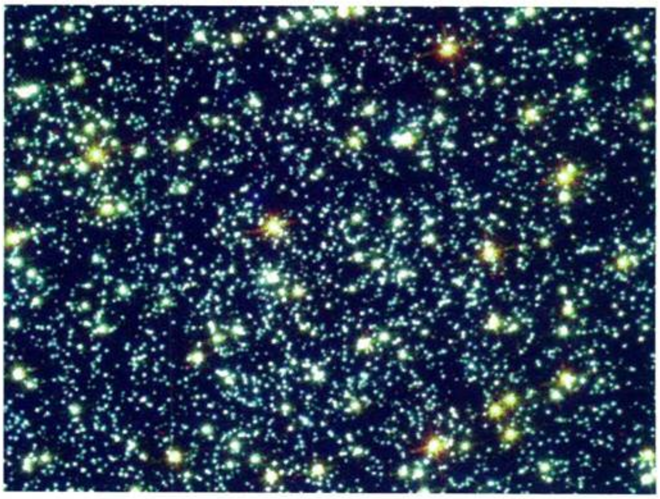
Stars Merge into One

▶ Globular clusters rank among the oldest objects in the universe. With ages of around 10 billion years, these clusters should be filled with old, cool, lightweight stars because hotter, heavier stars evolve rapidly and would have already died. Yet in some globulars, a few hot, apparently young stars still exist.

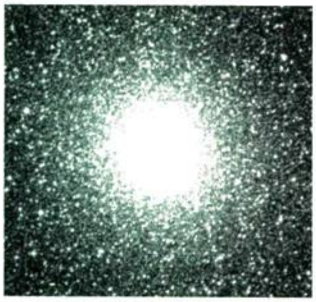
These enigmatic stars, called blue stragglers, have long puzzled researchers trying to piece together the evolution of globular clusters. Now a team of astronomers using the Hubble Space Telescope has, for the first time, confirmed that a blue straggler is a massive star formed when two smaller stars collide or coalesce.

Michael Shara of the Space Telescope Science Institute and his colleagues studied a blue straggler in the heart of the globular cluster 47 Tucanae, located about 15,000 light-years from Earth in the constellation Tucana. They measured the star's brightness, temperature, diameter, and rotation speed, from which they calculated its mass. The star turns out to have about 1.7 times the mass of the sun — nearly twice that of the largest main sequence star (one burning hydrogen) in the cluster. No star that heavy could have formed at the same time as the cluster and survived until now.

Astronomers think blue stragglers form either when two unrelated stars collide in a globular's crowded core or when the two stars in a binary system spiral together and coalesce. The rapid rotation of the 47 Tucanae straggler — some 75 times faster than the sun — leads Shara's team to favor the second scenario.



Several hot stars called blue stragglers lie in the globular 47 Tucanae. Viewed from Earth, stars in the cluster's core blur together (below), but Hubble clearly separates them (above). In this false-color image, red giant stars appear orange, main sequence stars are white/green, and blue stragglers are blue. Rex Saffer (Villanova Univ.), Dave Zurek (STScI), and NASA



SOLAR SYSTEM

Asteroid Shares Orbit with Earth

▶ How many natural companions does Earth have? If you thought there was just one, the moon, then you're in for a surprise. Planetary scientists have recently discovered a second — this one an asteroid. However, the new companion doesn't orbit Earth on a nice elliptical path like the moon but instead follows a complex, horseshoe-shaped path.

Asteroid 3753, also known as 1986 TO, is not a second moon of Earth but instead plays the role of a "traveling companion." Its complicated movement, which involves interactions with both the Earth-moon system and the sun, was discovered by Paul Wiegert and Kimmo Innanen of York University in Ontario, Canada, and Seppo Mikkola of Tuorla Observatory in Piikkiö, Finland.

The asteroid is in a spiraling horseshoe orbit. To envision a simple horseshoe orbit, think of a three-lane, circular race track. Earth is a large truck traveling at constant speed in the middle lane and the asteroid is a car moving a little slower in the outer lane. Just before the truck is ready to pass, the car switches to the inner lane and speeds up. It then starts to pull away from the truck but, being on a circular track, the car eventually catches up from behind. Just before it passes the truck, however, it again switches to the outer lane and slows down. Then the whole pattern repeats. In the case of 3753, the asteroid's path spirals as it performs these maneuvers.

The asteroid won't stay in this relationship forever. Over the course of thousands of years, gravitational interactions with Venus, Mars, and Jupiter will eject it from its current orbit. "Having waltzed with Earth for thousands of years," says Wiegert, "it may go looking for a new dance partner."

COLLISION WITH EARTH

An Impact on the Weather

▶ Frank Kyte, who discovered the impact of the Eltanin asteroid in 1981 when he was a graduate student, now believes that the planetoid may have been large enough to have devastated Earth's climate. Writing in the November 27, 1997, issue of *Nature*, Kyte and his 12 co-authors report that additional ocean-bottom sampling completed recently suggests that instead of being an estimated 0.5

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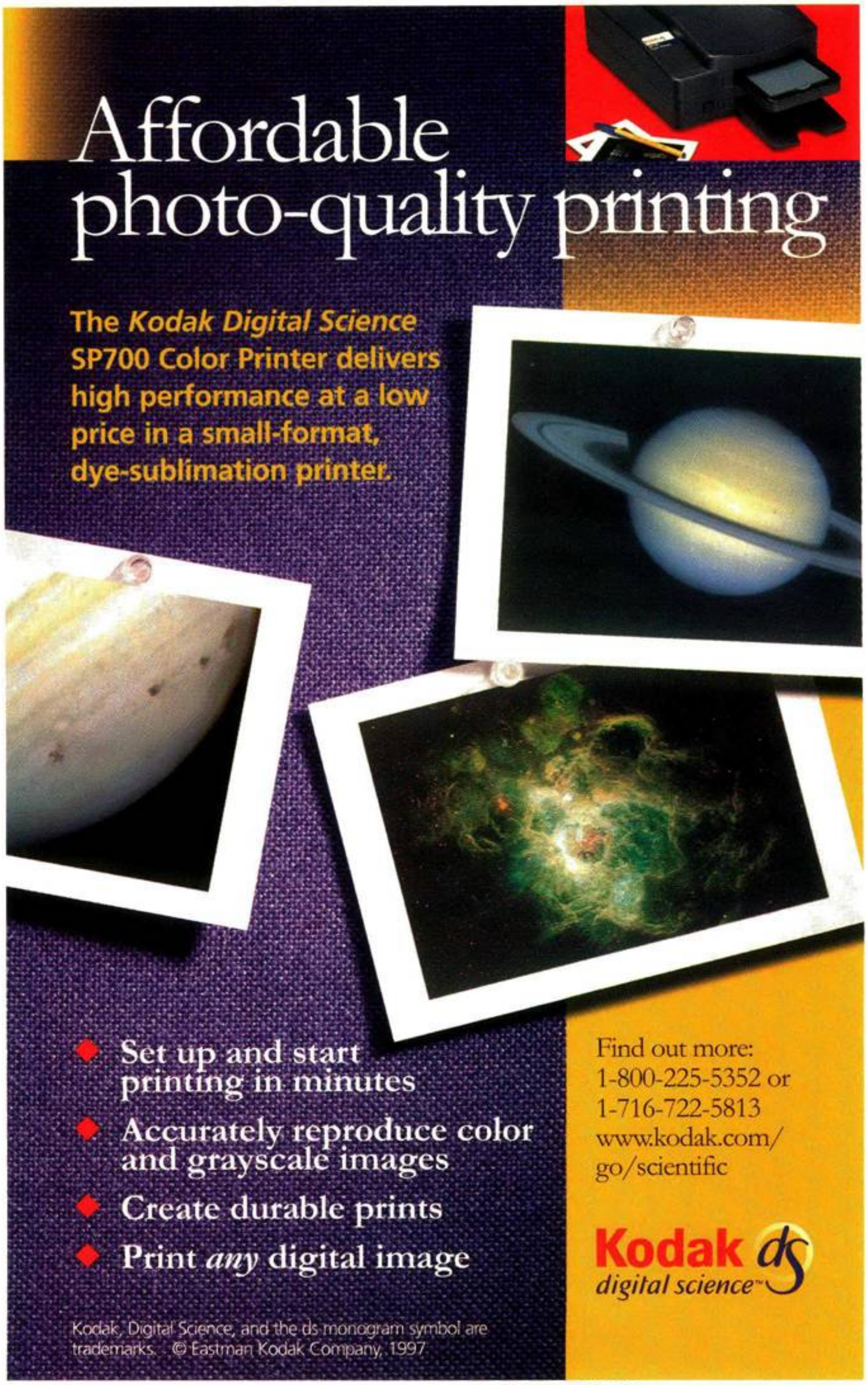

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kilometer in diameter, the asteroid was at least 1 km and possibly as large as 4 km across. That's big enough to have caused global "devastating megatsunamis," or 120-foot-tall tidal waves, after the object struck the Southern Ocean about 2.15 million years ago.

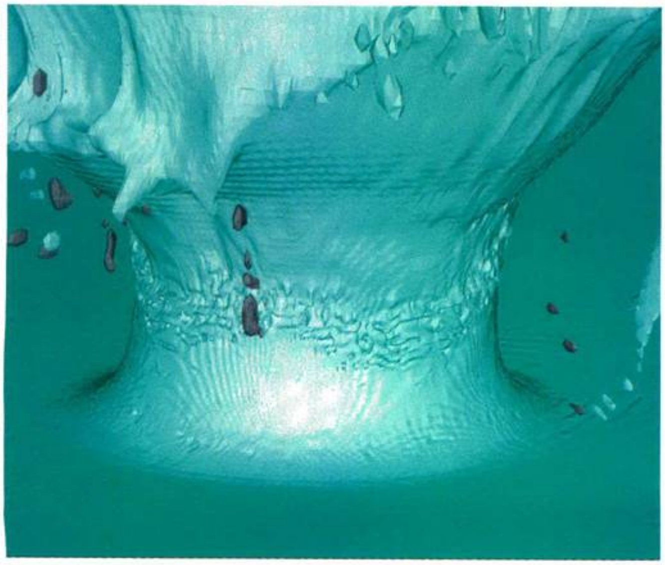
"This was right before a significant cooling event," said Kyte, a geochemist with UCLA's Institute of Geophysical and Planetary Physics. "Whether this impact was just a coincidence we can't say, but no one has looked."

There are about 140 known terrestrial impacts of asteroids, but 60 percent of Earth is covered by oceans. Water impacts would leave little evidence behind other than pulverized pieces of the asteroid buried under more recent sediments, terrestrial evidence of ancient tsunamis, or other subtle clues.

In the mid-1960s, the crew of the *USNS Eltanin*, an American research ship looking for evidence of ancient glacier activity, punched one of many 20-meter "piston cores" into the floor of the Southern Ocean about 1,400 km (900 miles) west of the southern tip of South America. The ocean bottom often is deeply covered with recent sediment but, fortunately, the ship passed above an area with little sediment when the fateful core sample was taken. The sample extended deep enough into the sea bottom to pierce a layer of asteroid debris. However, that core sample sat undisturbed on a shelf until Kyte examined it and discovered that it contained a region rich in iridium, a signature element of asteroids.

"I just got lucky to find this one," said Kyte. "The labs of sedimentologists and paleontologists all over the world have processed sediments from deep-sea cores, and I wonder how many (asteroid) impacts are sitting on the back of people's shelves." ■

Some 2 million years ago, an asteroid at least 1 km across smashed into Earth, perhaps triggering global cooling. In this supercomputer simulation of a similarly sized comet hitting water, the energy of 300 billion tons of TNT vaporizes the comet and large amounts of water and sends it flying across the globe.



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New Moons of Uranus — Update

Although it's still too early to pin down precise orbits for the two new moons of Uranus, further observations have narrowed the possibilities. Both orbit Uranus on eccentric paths and in the opposite direction from the planet's rotation, the first uranian moons to do so. Preliminary estimates indicate the brighter of the two orbits Uranus in about 495 days at an average distance of 6.5 million kilometers (4.0 million miles) and the fainter takes approximately 654 days to orbit once at an average distance of 7.8 million km (4.8 million miles).

Future Life on Titan?

When the sun expands into a red giant, will life spring forth on one of the icy moons of the outer solar system? In the November 15, 1997, issue of *Geophysical Research Letters*, the University of Arizona's Ralph Lorenz and his colleagues suggest Saturn's large, cloud-enshrouded moon Titan should warm up enough to permit life six billion years from now. The window of opportunity should last 500 million years, longer than the time it took life to get started on Earth.

NASA/JPL

Frigid Titan could one day warm up enough for life.

Quicker Quasar

Most of the thousands of known quasars vary erratically in brightness with periods as short as a few days. However, Australian graduate student Lucyna Kedziora-Chudczer has discovered one that varies 50 percent in less than an hour. "I've never seen anything like this — it is staggering," said David L. Jauncey, Kedziora-Chudczer's advisor. Because an object can't vary in brightness faster than it takes light to traverse the object, the short period implies a very small size, less than the diameter of Jupiter's orbit around the sun.

ESA Approves Mars Mission

The European Space Agency has given thumbs up for Mars Express, a $175-million mission to be launched in mid-2003. Under current plans, the spacecraft will consist of an orbiter and several landers, although the landers have not yet received funding. One of the landers will carry a rover capable of burrowing into the ground to search for evidence of past life.

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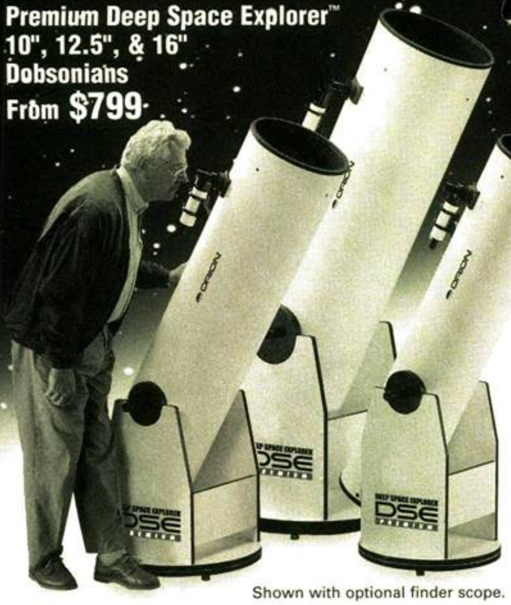

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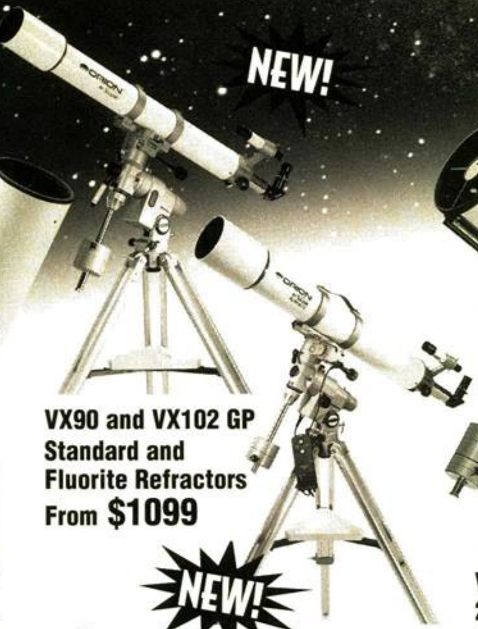

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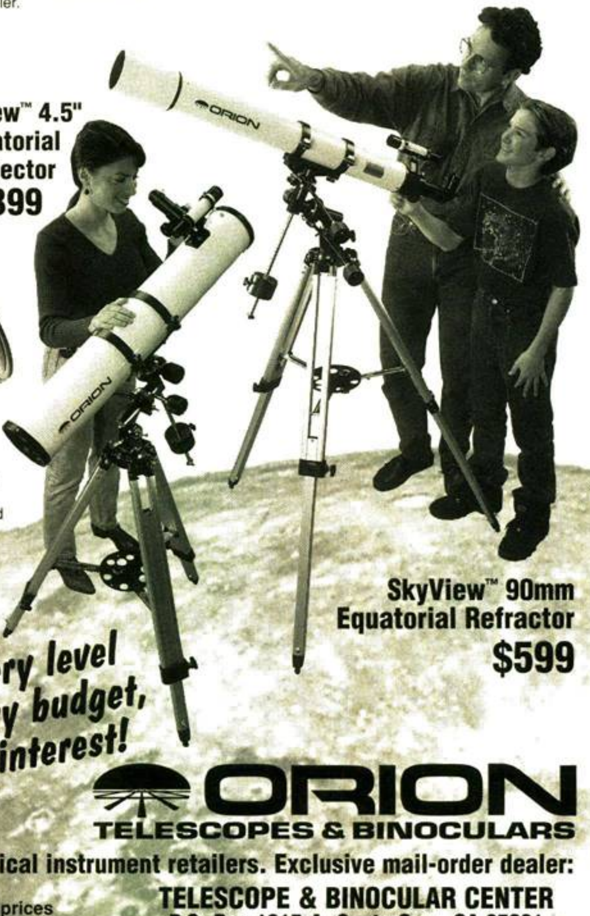

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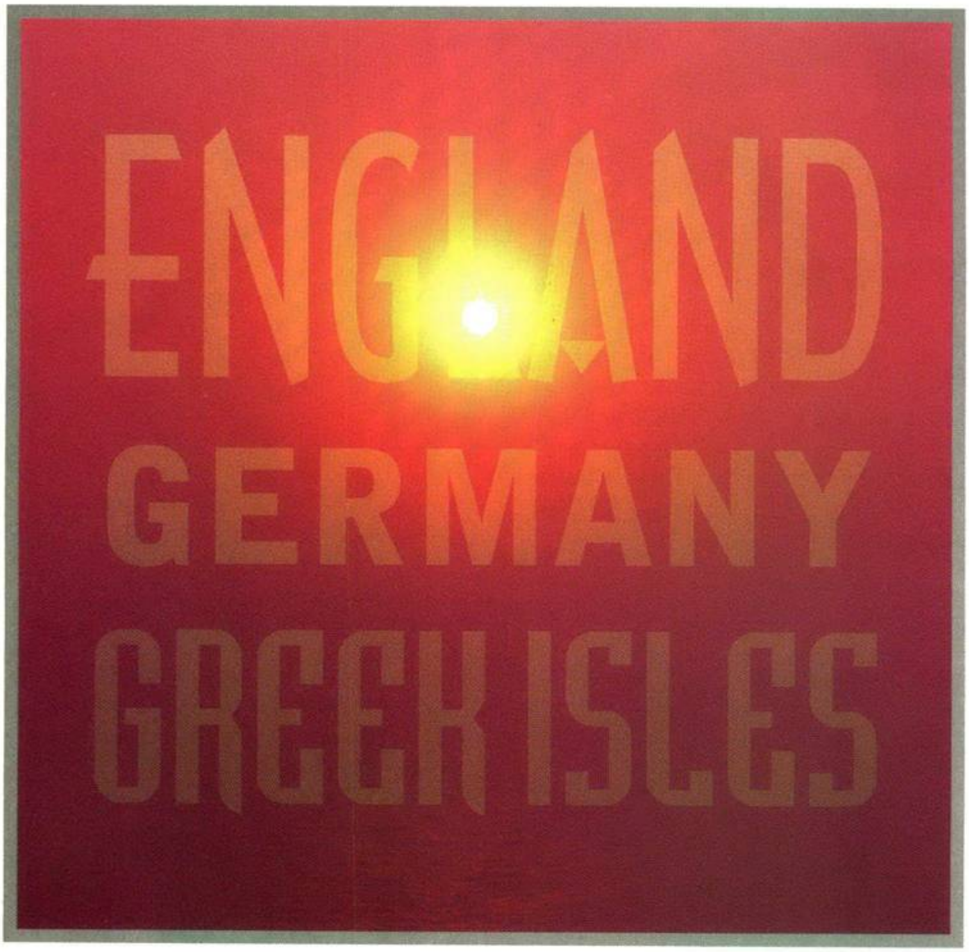

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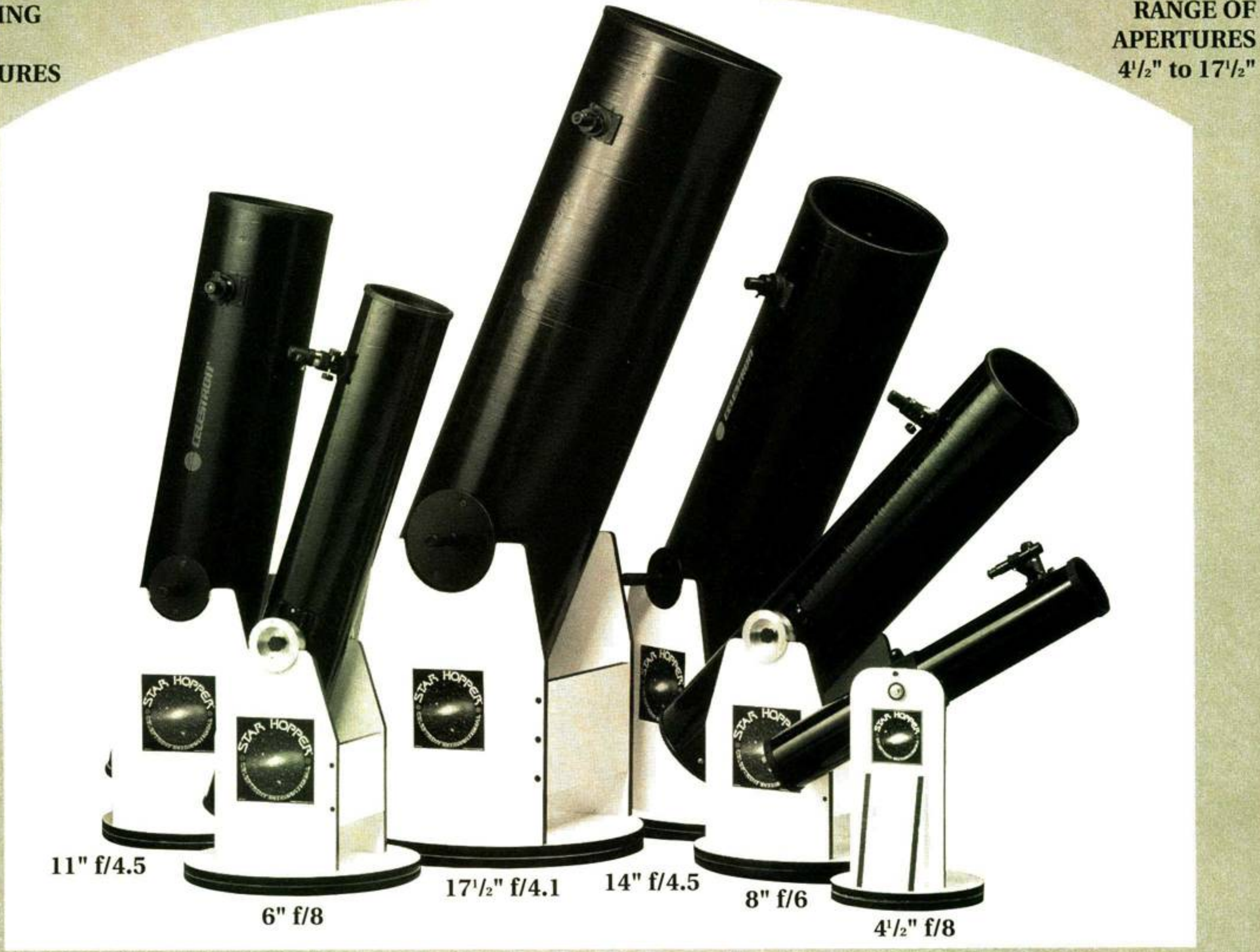

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IDEAS
THAT
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LOOK BACK

THE A LIST:

Astronomers have come up with many conjectures — some good, some not so good — that history has not treated kindly.

• Until the advent of the Space Age, most astronomers thought that craters on the moon were volcanic features. • Until the 1960s, astronomers thought Mercury rotated once every 88 days, the same period it takes to revolve around the sun. • In the 19th century, many astronomers thought a planet — dubbed Vulcan — existed inside Mercury's orbit, and it was even "seen" several times. • Observations a hundred years ago convinced many astronomers that artificial "canals," or at least vegetation, covered the surface of Mars. • Early this century, astronomers used apparent discrepancies in the positions of Uranus and Neptune to postulate the existence of a massive "Planet X." • Until observations by Tycho Brahe in 1577, astronomers thought comets were objects in Earth's atmosphere. • Until 1860, many thought that the prominences seen during solar eclipses were phenomena of the moon and not the sun. • Until this century, sunspots were thought to be holes in the sun's gaseous surface revealing a dark interior, or perhaps whirlpools sucking in cooler, darker gases. • Well into the 20th century, many astronomers thought that the planets formed when a passing star pulled material from the sun, which later coalesced. • Until this century, the sun was thought to lie at the center of the Milky Way Galaxy. • The French philosopher Auguste Comte wrote in 1835 of celestial bodies: "We understand the possibility of determining their shapes, their distances, their sizes and motions, whereas never, by any means, will we be able to study their chemical composition." • Until this century, most astronomers thought gravitational contraction powered the sun and other stars. • Until the 1920s, astronomers thought hot stars evolved into cool ones. • Until the second half of the 19th century, most astronomers thought all stars had similar luminosities. • From the 1930s until the 1980s, observations hinted that Barnard's star was orbited by two Jupiter-like planets. • Dark nebulae were long thought to be holes where stars were lacking, not areas where dust blocked stars from view. • In the 1930s, even after Karl Jansky's discovery of radio waves from the center of our galaxy, most astronomers felt radio astronomy was of no major significance. • Until the end of the 19th century, astronomers believed that the "ether" pervaded all space, allowing light to propagate. • Until the 1990s, many astronomers refused to believe that black holes existed outside of theory. • For many years after their discovery in the 1960s, quasars were thought by some to be objects ejected from galaxies. • Until the last few years, most astronomers thought that gamma-ray bursts occurred in the Milky Way Galaxy. • Until the 1920s, many astronomers thought the so-called spiral nebulae were gaseous regions in our own galaxy, not separate island universes. • For 1,500 years, astronomers believed in the geocentric model that places Earth at the center of the universe. • Until the 1920s, most cosmologists believed that the universe was neither expanding nor contracting, leading Einstein to introduce his "biggest blunder" — the cosmological constant — into his general theory of relativity. • Developed in the 1940s, the steady-state theory claimed the universe had existed forever and did not arise in a Big Bang.

Astronomy
25
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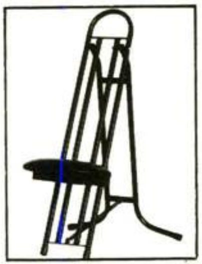

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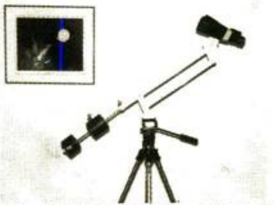

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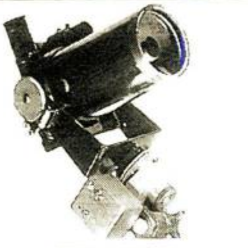

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Into Battle with NASA's CHIEF

Whether practicing down-to-Earth politics or envisioning interplanetary spacecraft, NASA Administrator Dan Goldin is a man on a mission.

by Andrew Lawler

IT'S A HOT, MUGGY MONDAY MORNING, and there is no NASA One, the sleek jet once reserved for the agency's administrator and other top space officials. Dan Goldin recently gave it up — "We save a million dollars a year," he says, walking briskly across the oozing tarmac at Washington's National Airport — and now the peripatetic NASA chief must borrow Federal Aviation Administration aircraft. But neither the heat nor the hitchhiking slows him down. This morning he is escorting a delegation of senators and congressmen to a rally at a NASA center on the Virginia coast to ease their worries that he will lay off workers at the site. And he won't make it home to his Capitol Hill rowhouse tonight at all, since he will be giving a late speech in Boston to a group of planetary scientists.

In between, the 57-year-old Goldin will find time at the office to oversee the most extensive empire in human history — one that includes the warrens of NASA headquarters in Washington, the space shuttle orbiting Earth, and the flotilla of planetary spacecraft on Mars, circling Jupiter, and cruising beyond the orbit of Pluto. That empire is held together by a staff of 20,000 people scattered across the United States, innumerable contractors, and a $13.6-billion budget provided by taxpayers. It is the dream job of a bookish boy from the Bronx who read science fiction and never doubted he would work in the space field. "It's my passion, it's my life," he says after nearly six years as agency chief.

With the zeal of a missionary, Goldin has set about converting a quiet agency that looked back with nostalgia on the

The Red Planet looms large over the shoulders of NASA Administrator Dan Goldin. The unqualified success of the recent Mars *Pathfinder* mission has helped vindicate Goldin's philosophy of smaller, cheaper, and faster space missions. All photos by Bill Ingalls/NASA

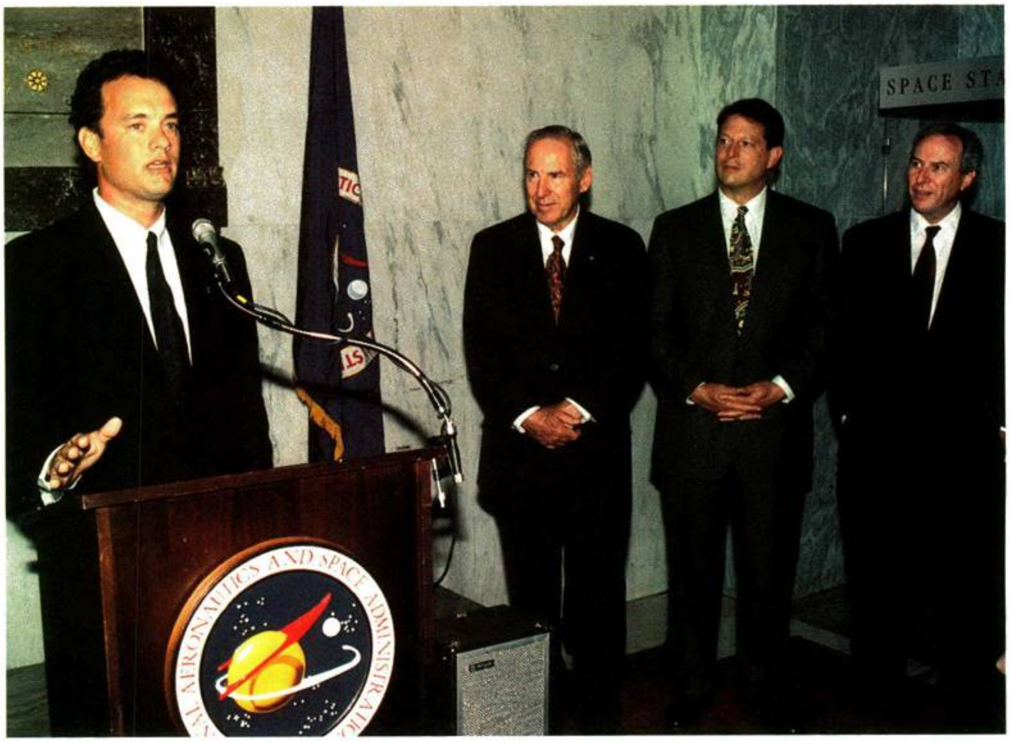
good old days of Apollo into a leaner and more aggressive organization aiming to reclaim its position as the pinnacle of U.S. science and technology. The effort has turned his hair gray. But in a town that either burns or spits out senior government officials and makes short work of idealistic reformers, he is the rare figure who has challenged the Washington status quo and — so far — won. The engineer and former corporate executive has turned the nation's planetary science program upside down, made friends with former foes in Russia, and taken a hatchet to the agency's bureaucracy, and he still has his job.

That's because his revolutionary zeal is tempered by what even his worst critics concede are keen political instincts. Goldin's forceful and sometimes erratic style has made numerous enemies among his own employees and within the industry he came from, but he has carefully and assiduously cultivated the right friends in the right places. That is why he is one of the few people who can claim both Vice President Al Gore and House Speaker Newt Gingrich as fans. And that is why he is the sole remaining senior political appointee hired by Republican President George Bush and kept on by Democratic President Bill Clinton.

It's a strange and contradictory combination, that political savvy which allows him to navigate the treacherous waters of Washington and the far-out vision of a future full of robots crawling across distant worlds and humans tramping through the red soil of Mars.

On this morning, however, it's Dan Goldin the politician who is firmly in charge as he schmoozes with the congressional delegation on the short plane trip to Wallops Flight Facility, a small complex that launches sounding rockets and weather balloons for scientists. This is no social visit. More than a year ago, a NASA team charged by Goldin with looking at ways to save money recommended that he consider shutting the aging facility down. But when word of that proposal leaked, Senator Barbara Mikulski (D–Maryland) went ballistic. Many Wallops employees live in nearby Maryland, and the senator was furious at the idea they might be laid off. So after calling Goldin on the carpet, she gathered up the other Maryland senator and a Virginia congressman or two, went to Wallops, and promised the angry and fearful employees that she

While visiting Tampa, Florida, for a "Town Meeting," Goldin and former astronaut Colonel Charles F. Bolden, Jr. stopped by an elementary school that features classes in space education.



Although Apollo 13's travails preceded Goldin's tenure at NASA, he was in charge when the movie hit the big screen. Here he watches with Al Gore and Apollo 13 commander Jim Lovell as Tom Hanks (who portrayed Lovell) speaks at the Rayburn House Office Building.

would keep the center open. They cheered her on.

Goldin, by contrast, got a different reception a few months later when he was vacationing at a cottage on a nearby beach. He and his wife dropped by Ray's, the local diner near Wallops and an institution that doesn't think highly of bureaucrats who would consider closing a facility that has been an economic linchpin for the depressed region since 1945. "The waitresses there knew more about the space program than most people in Washington," he recalls. Never one to avoid a good argument, Goldin debated the role of Wallops with them. "Pretty soon the cooks came out, the bartenders came out, and they beat me up pretty good," he says with a satisfied smile. "It was great."

Now, Goldin is back at Wallops, but this time with Mikulski and other lawmakers in tow and a firm commitment not to close the center. Employees at the facility cram the gymnasium and applaud as the delegation marches down the aisle to the stage. It's no surprise that the diminutive and spunky senator from Baltimore gets three standing ovations while Goldin receives mostly perfunctory applause. But Goldin can claim a face-saving victory of sorts. He has transferred some work from Goddard Space Flight Center — located in Mikulski's state of Maryland — to Wallops and has forced the facility's managers to rethink their way of doing business.

But did Mikulski — who, after all, is on the committee that funds NASA — strong-arm Goldin into saving a facility he thought should be closed? "That's an overstatement," the senator says with a merry grin after her speech to Wallops employees. "Let's just say I turned his interest from tepid to torrid." Goldin, who already has whittled NASA's work force down nearly 20 percent since he took the helm in 1992, refuses to see the Wallops plan as a sign of political expedience. Outside the gym, in the midday heat of an Eastern Shore summer, he insists that the facility could have been abandoned if employees had not come up with a bold plan to revitalize its work. And that plan, he says, justifies the center's continued existence. "There were no compromises," adds Goldin.

Then he pauses on the grass, one eye on the idling bus holding the waiting politicians behind tinted glass. "We live in a real world," he adds, before climbing aboard for a tour of the center.

The remainder of the visit is carefully scripted. But Goldin grows impatient with the coterie of handlers and public affairs officials and senior managers all looking at their watches and guiding the delegation along a well-planned circuit in an engineering building. He pulls aside one Wallops official. "Can I see some employees?" the irritated administrator asks. "I'm being whisked around, and there's no opportunity to meet with some employees."

He lags behind the shuffling tour to offer advice to a couple of college students on their way to engineering school after spending a summer at Wallops. "Don't get too comfortable," he tells them. "Stay the struggling student, and don't worry about earning loads of cash — that can come later. But most of all, stay in engineering — don't become lawyers!" He encourages a couple of employees displaying a weather balloon made of a new material that will allow it to remain aloft for 100 days. In the din of the nearby machine shop, he discusses commuting and shows off a picture of his grandchild to brawny workers. A very few seek him out — two African-American employees come up to shake his hand, murmur their support, then quietly slip away.

Despite Goldin's glad-handing, tension is still in the air. He flees lunch in the formal dining room and instead cruises the cafeteria, buys a chocolate ice cream cone and sits down with four startled employees. They listen politely as he talks about the need for constant education ("I take home biology textbooks and read them") and he assures them that the situation at Wallops "ought to be stabilized now." One woman finally breaks the awkward silence. "You want it straight?" she asks. "We're afraid." In the end, one of the group — who says she's a temporary worker — declines to write down her name for him. The suspicion is a revelation to the man who set in motion talk that the center would be closed. “I had no idea,” he says later. “The level of fear is incredible.”

The sentiment is a bit odd, given that Goldin is no stranger to angst in the workplace. While a senior manager at TRW in charge of building spy satellites along with NASA and commercial spacecraft, he was forced to lay off large numbers of employees when the company lost a Defense Department contract during the waning days of the Cold War. “It was the most horrible experience of my life,” he recalls. “We had no money, we had to do it, and I knew a lot of these people — I’d hired them, I knew their families.” He ended up in the hospital with an enlarged pancreas and a determination not to repeat the experience. “It was a real defining moment for me,” he says. “I started to become obsessive about coming up with ideas to find new work to protect the people who worked for me.”

That led Goldin to explore new ways to design and build spacecraft, and to look for fresh business opportunities. Under his guidance, TRW set up innovative technology programs and then won a number of small satellite contracts with the Air Force. He traveled to South Korea and Taiwan looking for ways to build components more cheaply. “I was obsessive about having to change because I did not want to go through another layoff,” says Goldin. He watched his colleagues in TRW’s automotive sector cut production costs and improve quality and sought to apply that to the space field. But he ran into a wall when he suggested that NASA build smaller Earth observation satellites. The dogma at the time was that larger was better, because it allowed researchers to place many instruments on a single spacecraft and obtain simultaneous data. NASA forced him to withdraw a paper at an international conference laying out the case for smaller and cheaper satellites. “I was told if you don’t withdraw that paper, you’ll never get any more NASA business,” he recalls with anger.

His strong views on the advantages of smaller, cheaper, and faster missions caught the attention of Vice President Dan Quayle’s staff at the White House National Space Council in 1992. They were fed up with the bad news coming out of NASA — Hubble Space Telescope myopia, space shuttle launch delays, and embarrassingly hefty price tags for a human mission to Mars backed by Bush. “Five or six years ago, NASA was considered part of the problem, it was a laughingstock that symbolized everything that was wrong with Washington,” says one aerospace official who has worked with the agency. So at Quayle’s urging, Bush fired the previous administrator, Richard Truly, a genial former astronaut with a quiet Southern accent who had rarely rocked the NASA boat. And he hired Goldin.

What the agency got was a tough industry manager with a reputation at TRW for a quick temper, an unforgiving style, and a single-mindedness that won him the nickname Captain Crazy. With the Cold War over and the White House eager for a revamping of NASA, Goldin found an opportunity unmatched by almost any previous agency chief. “He is the first administrator in 30 years to have the chance to redefine the U.S. space program,” says the aerospace manager. “We’re going to remember NASA pre-Goldin and post-Goldin.”

He quickly went to work, taking up the space council’s slogan of faster, cheaper, better. Most major NASA efforts — from the space station to planetary probes — underwent painful reviews. Spacecraft programs were canceled or scaled back. Many senior officials in Washington with ties to the old regime were given the choice of resignation or reassignment to remote NASA centers. And within a couple of years, virtually every director of the dozen agency centers that form the backbone of NASA had left. In their place he put a new generation of managers less likely to buck his vision of smaller spacecraft launched more frequently.

Meanwhile he worked tirelessly to charm and cajole members of Congress like Mikulski who oversee the space agency, visiting their Capitol Hill offices and buttonholing them during visits to their districts or states. His tenacity won him critical support from lawmakers who otherwise might have opposed his plan to revamp the agency or voted to cancel the controversial space station. When Bill Clinton became president in 1993, Gore argued that Goldin should be allowed to continue his efforts. The administrator proceeded to convince the new White House to throw in their lot with the Russians to build a space station rather than cancel the effort, which had been plagued with cost overruns. He became the poster child for Gore’s efforts to reengineer government.

By now it’s early afternoon, and Goldin is back in his office, which overlooks a Washington freeway, the Potomac, and the Pentagon. A few meetings, the drudgery of performance evaluations, and some phone calls. Then he is on his way to the Massachusetts Institute of

Technology in Cambridge, where he is due to speak to planetary scientists. Before the speech he meets with a dozen researchers at an Italian restaurant not far from the university. Munching on pepperoni pizza, he listens to their complaints, asks them about the latest findings from Galileo's visit to Jupiter, and spars with them over what he sees as their failure to work more closely with biologists who could help in the search for life beyond Earth. Then he jumps in a cab for the quick ride to MIT.

The dinner leaves some of the researchers rattled. "We worry about Dan Goldin," says one. "He's a loose cannon." The upheavals of the past few years have taken their toll on established members of the science community used to the slow progress of a handful of major programs. Now there are a bewildering number of smaller missions, but without additional funds. NASA's budget, in fact, has dropped nearly $1 billion since Goldin took charge. And with his hand on the shrinking purse, Goldin's whims can determine a researcher's career for years to come. That sense of concern, even fear, pervades discussions with NASA employees and outside researchers about the administrator. But Goldin dismisses this as "monsters in their heads." He says, "I don't knowingly cause fear. I stir the pot, I try to get people to think." But he admits that he has to work hard to control himself.

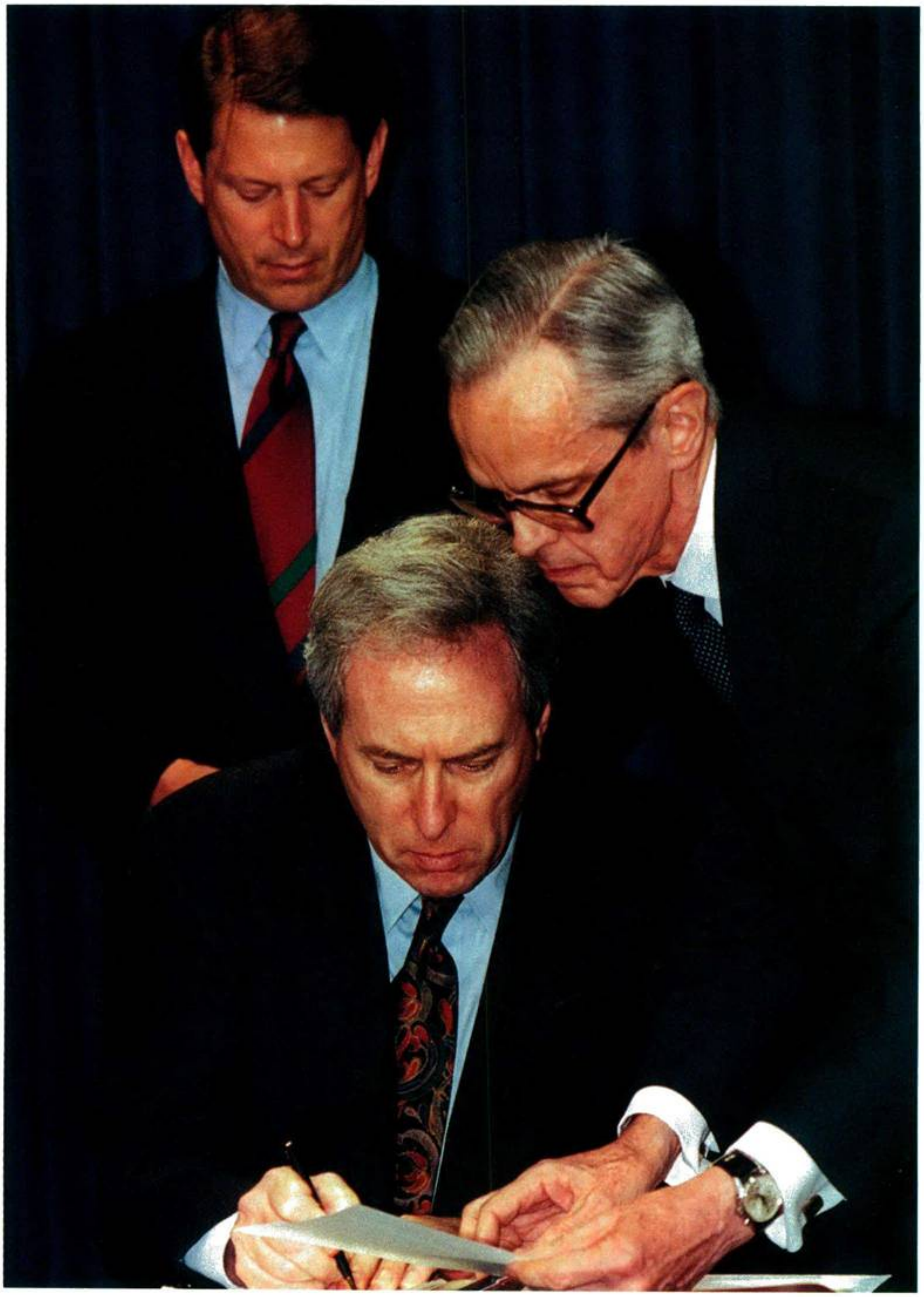
The NASA chief clearly revels in the power of a job that allows him to show off the latest pictures from the martian surface to the vice president, talk to awed schoolchildren about space exploration, and blast recalcitrant aerospace contractors. But he insists it is the visionary, not the politician, who is firmly in charge. "I came here on a mission," he says. "I didn't come here for any other reason but a genuine concern about the future of long-term research in this country."

At the Jet Propulsion Laboratory, Goldin examines a toy model of the Mars Pathfinder rover, Sojourner, with flight system manager Brian Muirhead (left) and chief project scientist Matthew Golombek.

Goldin joins California governor Pete Wilson and his wife to view a three-dimensional image of Mars on the computer screen of Ted Blackman, a virtual reality engineer at NASA Ames Research Center.

Despite his obvious nose for politics and an ambitious streak a light-year wide, it is hard to doubt the sincerity of his space-buff idealism that began when he went to New York's Hayden Planetarium as a boy. His father, who earned a degree in biology during the Depression and later became an elementary school teacher, played a key role in his interest in science. "He exposed me to astronomy — we looked at stars through a telescope, he showed me children's books about astronomy, and I built model planes and even model rockets," he recalls. "And I read science fiction."

Goldin had already decided on an engineering career as a way to realize his interest in space when a graduate student walked into his freshman physics course at Hunter College in New York and wrote on the blackboard: "Sputnik is watching you." Goldin recalls "there was bedlam" in the classroom. "I was so excited," he adds. A few years later he joined the new space agency and worked at NASA's Lewis Research Center in Cleveland on advanced propulsion concepts that could take humans to Mars. But by 1967, the excitement of the civilian space program began to fade. "I sensed a change," he says. "My sense was that after Apollo, nothing was going to happen." So he joined TRW, where he worked in the blossoming field of communications spacecraft. Then he disap-



With Vice President Al Gore looking on, Goldin signs a cooperative agreement between the United States and Russia.

peared into the highly classified world of spy satellites for more than a decade. But, he says, his love of civilian space always remained in the back of his mind.

As faint stars come out over Cambridge, it is the visionary in Goldin that emerges. Before a few hundred planetary scientists, he paints a compelling future in which solar sails whisk probes to Mercury and Venus, while flying robots darken the skies of Mars and aquabots swim in the liquid under the frozen crust of Europa. He foresees hybrid machines that combine biological components with traditional mechanical and electronic ones, and thinking spacecraft that can make their own decisions. "We will make the last 50 years seem like child's play," he promises the audience. He wants graduate students early in the next decade to be able to design interstellar probes. No talk of budgets, political compromise, or personnel constraints.

The engineers and scientists in the auditorium clearly are not sure what to think of this man. Some grumble and snort during Goldin's talk, skeptical of the practicality of his ideas. Others are believers. "He's made great changes for science," says Jackie Green, a young researcher from NASA's Jet Propulsion Laboratory in Pasadena, California, which oversees most deep space probes. "It was demoralizing coming out of grad school to find that planetary science was no longer a national priority." But with faster and smaller missions on the books, "it's a thrill a minute — something's always hopping."

The next morning, Goldin is on an early flight back to Washington; this time he's on a commercial US Airways flight rather than an FAA jet. He's in good spirits despite a night in a dreary Howard Johnson's hotel room with faulty air conditioning. The Wallops crisis has passed, NASA's 1998 budget looks secure in Congress, and the success of the Pathfinder landing on Mars has won the agency international acclaim. He talks of his embryonic plans for a human mission to Mars and of the search to find terrestrial-like planets in other solar systems — and perhaps life.

So what does a missionary like Goldin do after this job? "I don't know the answer to that," he says after a moment's thought. "I've got to go up the mountain in the next year or so and figure that out." Then the plane is at the gate, and Goldin is rushing off across the terminal, his aides struggling to keep up.

Andrew Lawler covers politics for Science *magazine. He has been writing about the space program since 1984.*

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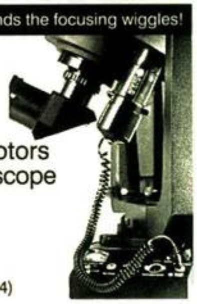

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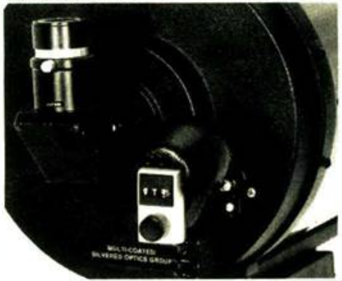

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TAKE A DEEPER LOOK AT YOUR UNIVERSE

The Bettmann Archive

Find the 3-D glasses inserted in this magazine and share the magic of added dimension in our images of planets, moons, and nebulae.

When the stereo images delivered by Mars Sojourner began to appear as giant 3-dimensional posters — accompanied by those silly 1950s glasses, I knew what we had to do. We had to share the fun with our readers. We began to investigate the production standards for printing anaglyphs (the slightly out-of-register images that produce three dimensions when you use the correct eyegear). We began shopping for glasses. Then, when we found out how much they would cost, we began shopping for some kind souls who would sponsor our effort.

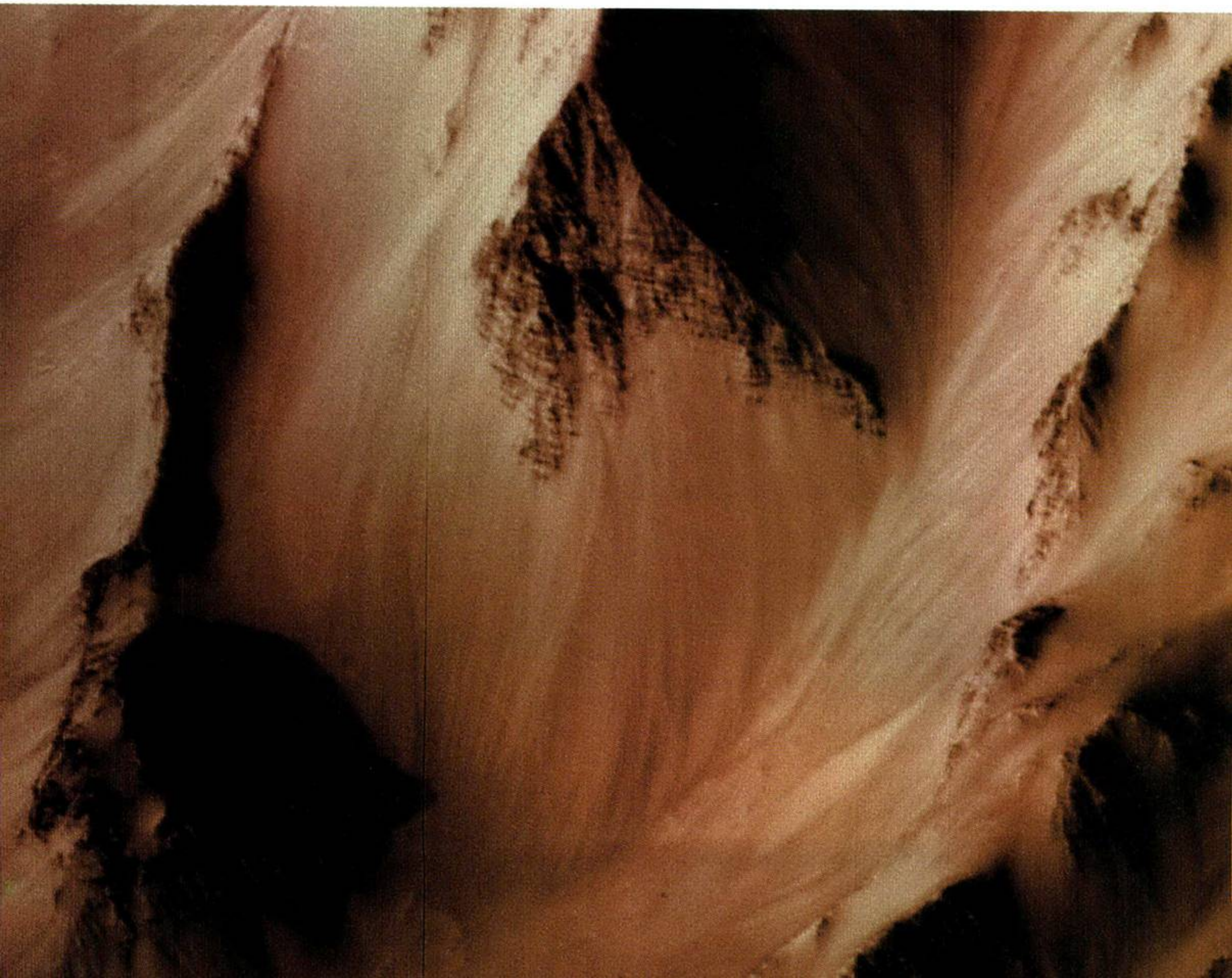
Lots of my colleagues gave me bewildered and skeptical looks when I suggested this project, but we pushed ahead and pretty soon everyone here was excited about it. We hit some big snags — like postal regulations we hadn't thought to check. *Astronomy* staff members pulled hundreds of small strings to make this happen — and here we are with a 3-D production. In the three stories that follow, two about Mars and one photo gallery of the universe, you will find 17 pages of wondrous imagery. The two Mars stories will also update you on the most current findings from the Global Surveyor and Pathfinder missions. The photo story will simply dazzle you with good visions.

We want to take this opportunity to thank the folks who helped us bring you the two pair of 3-D glasses you'll find in every copy of the magazine: Meade, Oceanside Photo and Telescope, and Edmund Scientific were your benefactors. Rainbow Symphony built the glasses and guided us carefully through their production. *Astronomy* magazine has provided additional new 3-D images to these four companies to place on their own websites so you can use your glasses beyond the pages of the magazine. And look for even more 3-D images at *Astronomy*'s website as well: www.astronomy.com. ▣

Red Planet
Rendezvous

Mars Global Surveyor will help answer the big questions about the Red Planet's past climate and ability to support life.

by William K. Hartmann



With new discoveries about Mars's magnetic field and striking new images of dune and dust deposits, Mars Global Surveyor has swung into action around the Red Planet.

Mars Global Surveyor — or Surveyor for short — rocketed skyward from Kennedy Space Center on a pleasant November day in 1996. Nearly a year later, on September 11, 1997, it coasted into an elongated, 45-hour orbit around Mars. By the third orbit, it was making new discoveries about Mars, including the discovery of a weak magnetic field.

During the early orbits, Surveyor's high-resolution images showed a planet with stratified rock layers and old craters awash in windblown dust deposits that look like snow drifts. One of the first high-resolution images, for example, showed one of the sinuous martian channels, or dry riverbeds, with a beautiful, never-before-seen row of dunes running down its center. As good as the early images were, Surveyor will eventually provide images with even better resolution, perhaps showing details as small as five meters.

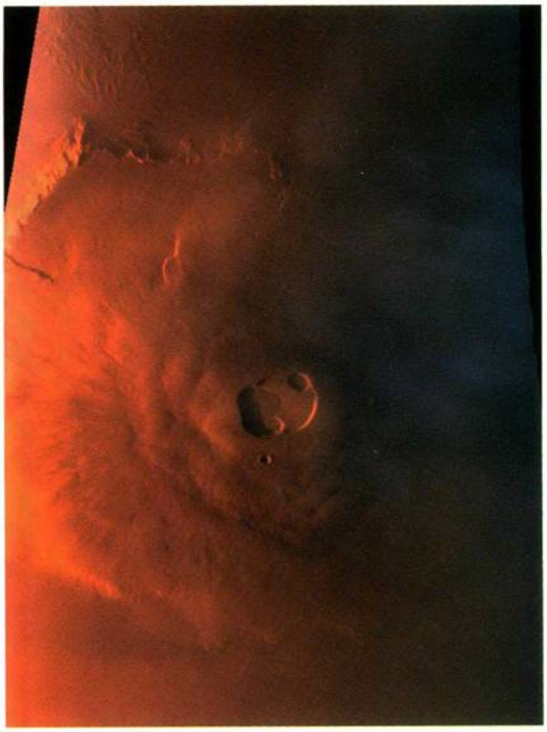
Dipping into the Atmosphere

The early success of Surveyor was given scant attention in the news media. Few newspapers ran the images of Mars that were released on October 4, 1996, one exception being the *New York Times*. Apparently, the media burned out on the Mars Pathfinder Independence Day extravaganza, which mesmerized a nation as the lander radioed back spectacular color images from Mars and deployed a rover to measure compositions of martian rocks. Surveyor was actually launched a month before Pathfinder, but Pathfinder reached Mars first because it was on a faster trajectory.

The equally exciting scientific story is that Surveyor, despite problems, is churning out stunning images and new compositional data that beautifully complement the Pathfinder data. Together, the two missions represent the first chapter in a new book of Mars exploration. Pathfinder and Surveyor were each built for less than $280 million, considerably cheaper than the Viking missions of the 1970s. To keep costs down, Surveyor included some spare parts from the failed Mars Observer mission.

A serious problem arose after Surveyor was placed in an elliptical orbit that dipped into Mars's atmosphere on one side of the planet. The original plan was to use the atmospheric drag force to slow down the spacecraft, reducing the altitude of the orbit's high point and bringing the spacecraft into a 248-mile-high circular mapping orbit by March 1998. Alas, this five-month process, called aerobraking, had to be terminated as of mid-October. The problem involved one of Surveyor's two solar panels. Like butterfly wings, the panels were designed to flip open after launch, from their folded launch position into a locked flight position. One panel apparently didn't quite make its way into position. During the October aerobraking orbits, that panel developed bizarre movements. Flight controllers elected to raise the low point of the orbit out of the atmosphere and temporarily discontinue aerobraking until the problem could be analyzed.

This Mars Global Surveyor image shows rock outcrops in Valles Marineris. The 3,200-foot (1,000 meter) rock face at the top has about 80 layers, which record a complex geological history. NASA/Malin Space Science Systems



On October 20, 1997, Mars Global Surveyor imaged the spectacular volcano Olympus Mons, which towers 82,000 feet (25 km) over the average Mars surface elevation. For comparison, Mt. Everest rises only 29,000 feet (8,850 meters) above sea level. NASA/Malin Space Science Systems

By early November, controllers settled on a final mapping orbit that will be a mirror-image of the original orbit; one that will enable the mission to achieve most or all of its scientific objectives. Instead of the spacecraft taking data from north to south on the sunlit side of Mars, it will do so from south to north in the sun. The spacecraft, however, won't attain its mapping orbit until mid-January 1999, and full-scale scientific observations won't begin until mid-March 1999. In the meantime, Surveyor will continue to take high-resolution images of the martian surface, such as the one on the facing page.

The Big Questions

To formulate a game plan for Surveyor, planetary scientists drew up a list of the big questions that still remained after 25 years of Mars exploration. In 1971–72, Mariner 9 revealed young volcanic features and the apparent dry riverbeds or "channels" (not to be confused with canals). In 1976–77, the two Viking landers showed that the surface soil is sterile, though chemically reactive. The two Viking orbiters revealed more details of the riverbeds and also identified features that some geologists interpreted as shorelines of ancient lakes or seas and possible scars of ancient glaciers.

A once-wet Mars might have been habitable for life. Questions of biology were magnified in 1996,

At the bottom of this Surveyor image is a small portion of Valles Marineris. The canyon system is up to 150 miles across and four miles deep; the small gorges jutting out of Valles Marineris are larger than Arizona's Grand Canyon. Late afternoon clouds inhabit the canyon system.

NASA/Malin Space Science Systems

when scientists examining a meteorite from Mars discovered carbonate globules containing what might be microscopic fossils of martian microbes. The reality of the fossil microbes has been controversial ever since (see "No Martian Microfossils?" AstroNews), but the carbonate globules, inside cracks in the rock, support the idea of ancient running water on Mars. Water that has percolated through soil or run across the ground contains dissolved salts and other compounds. When such water accumulates in ponds and then evaporates, salt and carbonate molecules are left behind (this process forms bathtub rings). Salts and carbonates of this type are called evaporites; the carbonates in the Mars meteorite seem to be this type of deposit.

Today Mars's surface is dusty, dry, and frozen. Liquid water freezes or evaporates almost instantly there because of the cold temperatures and low atmospheric pressure. But water exists in three other forms: as polar ice, as permafrost under the soil, and as molecules trapped in minerals.

Given these facts, Mars research now focuses on two categories of big questions. The first concerns the climate and the water. How could liquid water exist in the past to carve the river channels? Was the ancient climate radically different, perhaps with a thicker atmosphere that would have allowed liquid water to be stable? Or were there only transient outbursts of water (perhaps from volcanically melted permafrost), which gushed out, flowed across the surface, and evaporated? How much water was there? Were there really seas at one time? If so, how long did they last?

The second big question involves life. If Mars had running water or seas, did life evolve? If so, did it die out as Mars's climate became more forbidding? Or does it still exist somewhere on Mars in primitive, microbial forms — perhaps hidden in warmer soil layers under the permafrost? If life never developed on Mars, why not? If life failed to evolve on a planet with running water, does this tell us that life is rarer in the universe than we might suppose? Notice that either a positive or negative finding would be profoundly meaningful. If we find life on Mars, we learn about how alien life might evolve on other worlds. If it never formed, we get a lower limit on the kinds of planets that might harbor alien organisms.

Answering the Questions

Once we've defined the two big questions, how do we use Surveyor and Pathfinder results together to help answer them? Anyone who watched the heady first days of Pathfinder TV coverage knows that the scientists were excited about finding evidence of massive water flows on the planet. Personally, I think they got too excited. I saw one famous Mars geologist — a friend of mine — point to apparent rock layering on the distant "Twin Peaks" and say that this proved that massive amounts of water had deposited sediments in that area — just as he had always thought. This was exaggerated, at best; many hills and cones in the desert southwestern United States display volcanic strata or windblown strata that have nothing to do with water-borne sediments. Finding strata isn't the ultimate test of ancient water.

A more systematic Pathfinder search for ancient water came from the chemical analyses carried out by the Sojourner rover. As mentioned above, when groundwater evaporates, it tends to leave evaporite deposits that are rich in carbonates, sulfates, and salts. The Viking landers found that the caked soils had sulfates and minor amounts of carbonates, but that's not enough to prove that ancient seas existed in those regions. The Pathfinder cameras show some spots where the soil seemed lighter colored, but Sojourner did not find massive carbonate deposits; generally the soil was not dramatically different from what the Vikings had measured.

This brings us back to Surveyor. It carries three primary instruments: a high resolution Mars orbital camera (MOC) built by Mike Malin and Malin Space Science Systems in San Diego, a thermal emission spectrometer (TES) built by Phil Christensen and colleagues at Arizona State University, and the Mars Orbital Laser Altimeter (MOLA), built at NASA's Goddard Space Flight Center in Maryland. Unlike most spectrometers, TES measures not reflected sunlight, but the infrared radiation emitted by surface heat. In field tests, TES can detect and map detailed deposits of rock types that trained field geologists on the ground often miss. TES can also detect evaporite minerals, which means that it is a valuable tool in the search for possible ancient lake beds.

The altimeter can search for the low points in the global topography, where massive water flows might have produced temporary lakes or seas. This is where the evaporites should be found. Cameras imaging details only a few meters across may reveal formations resembling ancient dry lake beds on Earth. The spectrometer can then test whether those areas systematically show different rock or soil composition than other areas.

Working together, the three instruments might be able to track down the elusive areas of evaporate deposits that may indicate where ancient lakes or seas once shimmered in the martian sun; or they might prove that no such deposits exist.

A New Challenge

New discoveries aren't easy, and the first pictures taken by the Surveyor camera revealed a challenge we'll have to face. They show massive deposits of dunes and dust drifts that have covered some of the older topography. Football-stadium-wide craters are often engulfed in drifting dust. If the dust deposits are too deep and too universal, the spectrometer might only see the same spectroscopic signature — that of well-mixed dust in the upper few centimeters of every geological region on Mars, in the same way that the two Vikings and Pathfinder found the dust to be similar at all three sites. Fortunately, some images show regions where dust deposits seem to be blowing away, exhuming old surfaces. Perhaps the trick will be to find old deposits that have been recently exposed.

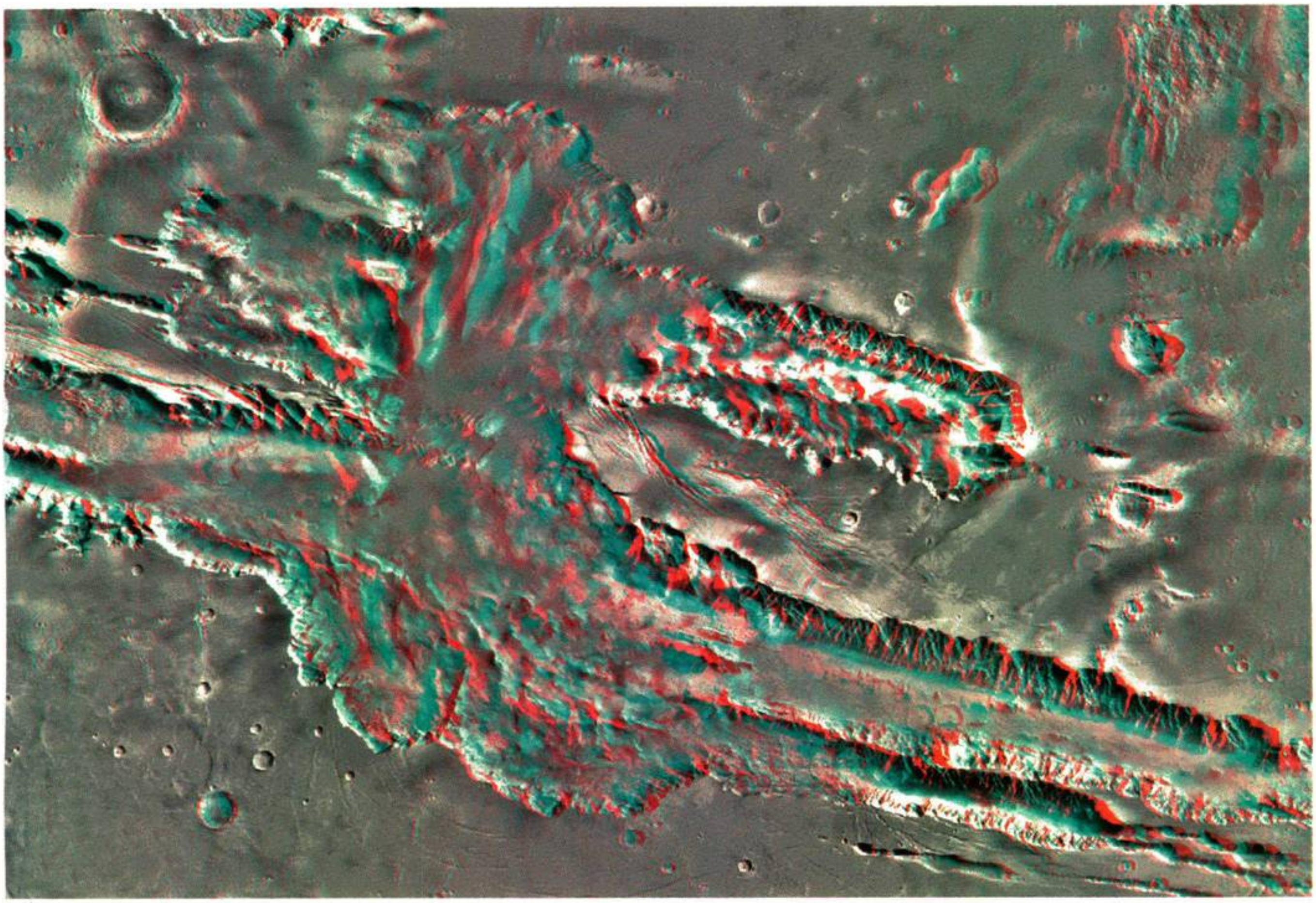
My own research is another way to get at the big question of ancient climate change on Mars. The planet shows a deficiency of small craters. The hypothesis I've been testing in Viking and early Surveyor data is that the loss of small craters happens because blowing dust fills in the small craters faster than the big ones. If so, by measuring the numbers of small craters, we can determine the average rate of dust infill and characterize the martian erosive environment. Conceivably, this work could show higher erosion or deposition rates in earlier Mars history — helping us answer the big question about the ancient martian climate.

Mars Global Surveyor has already taken exciting data about Mars, and it will be fascinating to watch the evolution of the mission — and the results — as engineers at Jet Propulsion Lab alter the orbit of the spacecraft and scientists scramble to keep optimizing the data flow. The best is yet to come. ■

William K. Hartmann is a senior scientist at the Planetary Science Institute in Tucson, Arizona, and a member of the Mars Global Surveyor imaging team. His novel Mars Underground *(Tor Books, 1997) is a story of Mars exploration. He is also an accomplished artist.*

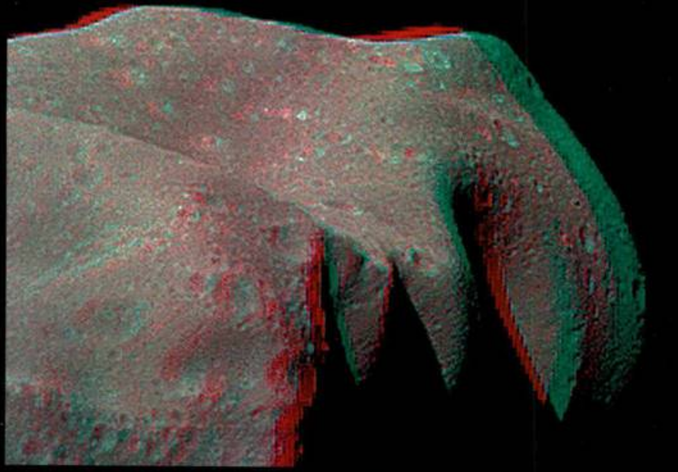
Mars Global Surveyor will be imaging Valles Marineris (below) at high resolution. This 3-D mosaic comes from Viking orbiter imagery. The canyon system would stretch from New York to San Francisco.

Original photo mosaic by USGS; 3-D visualization by Ambroziak Third Dimension Technologies, Inc.



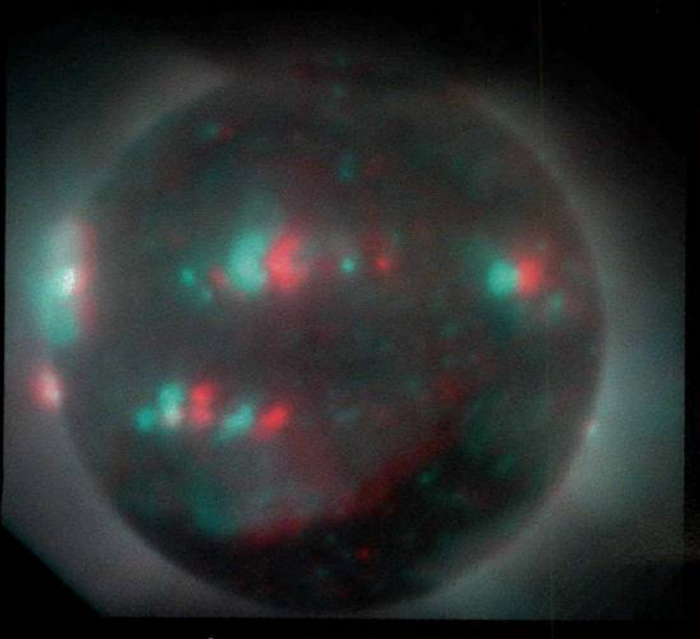
THE UNIVERSE IN 3-D

All images unless otherwise noted: Paul Schenk, David Gwynn, James Tutor; 3-D Tour of the Solar System; Lunar and Planetary Institute

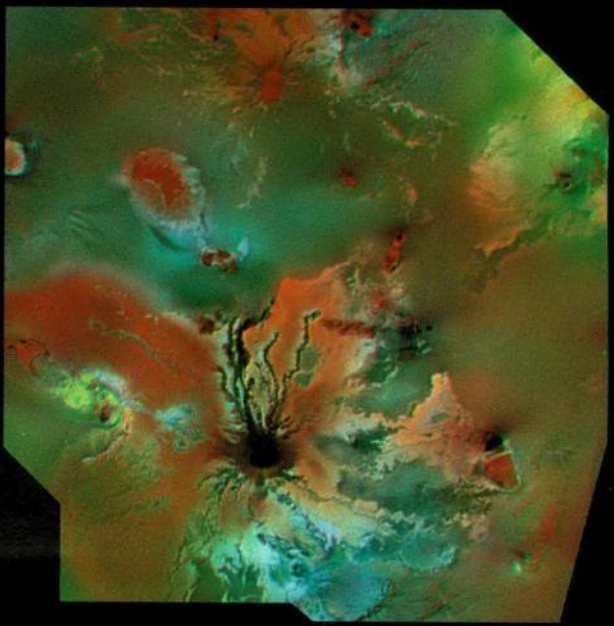


Asteroid Ida

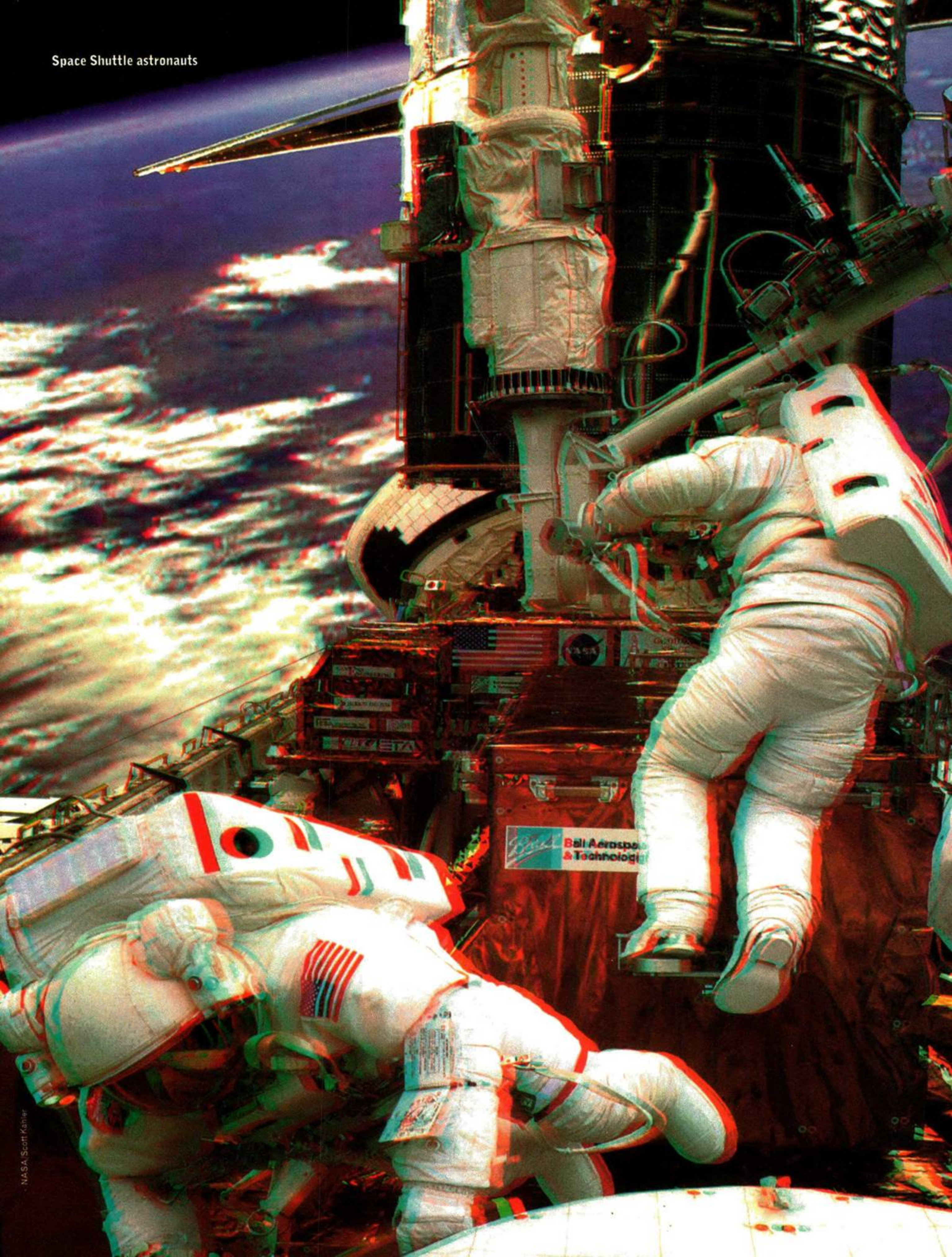
Books and magazines show us the universe in two dimensions. But because the physical universe exists in at least three dimensions, we've made it our mission to add some depth. To see a variety of celestial objects in their full 3-D glory, use the special glasses inside this issue. May you come away with a deeper appreciation of the solar system and galaxy that surround us.



Sun: x-ray image from Skylab



Io: volcanic flow from Ra Patera



NASA
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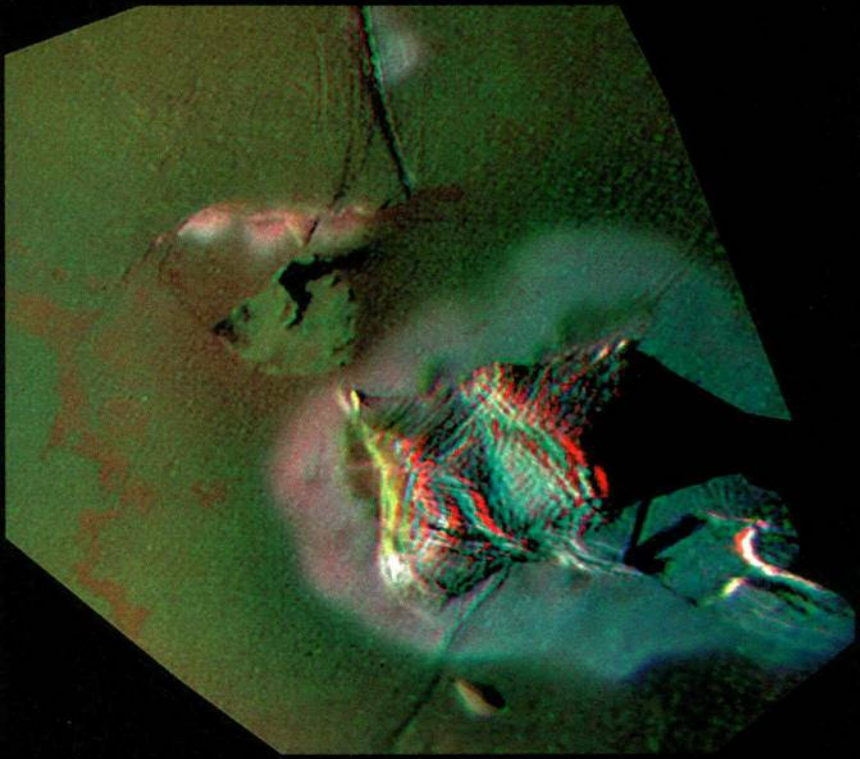
Space Shuttle astronauts

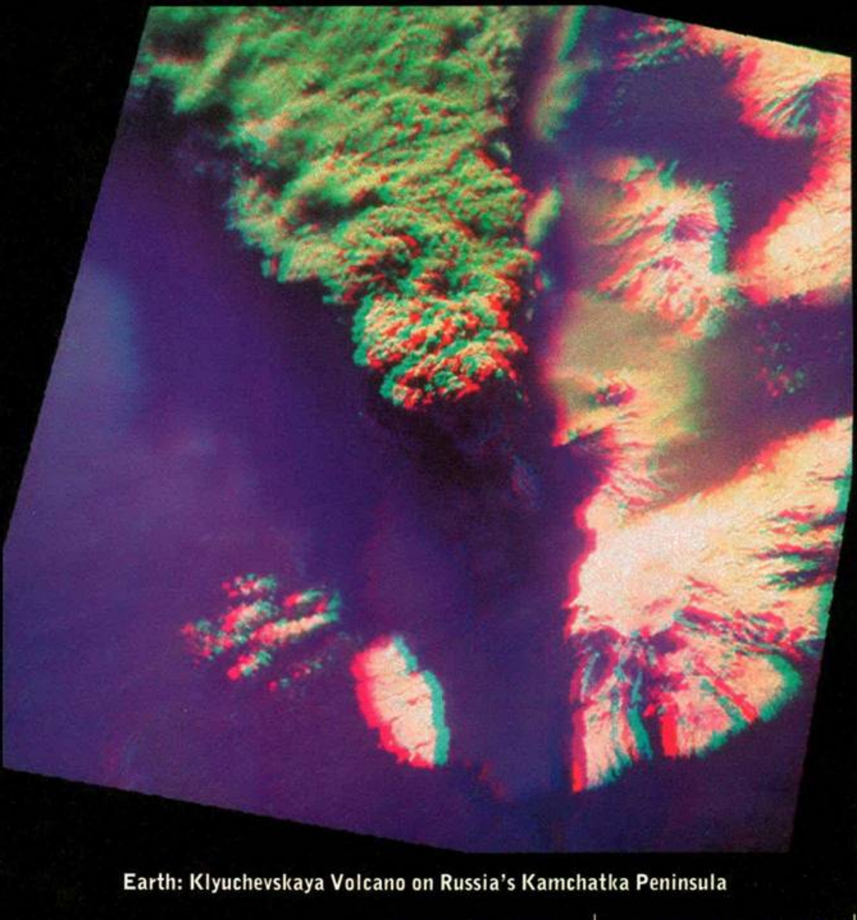
NASA/Scott Kähler

The giant pillars of the Eagle Nebula (M16)

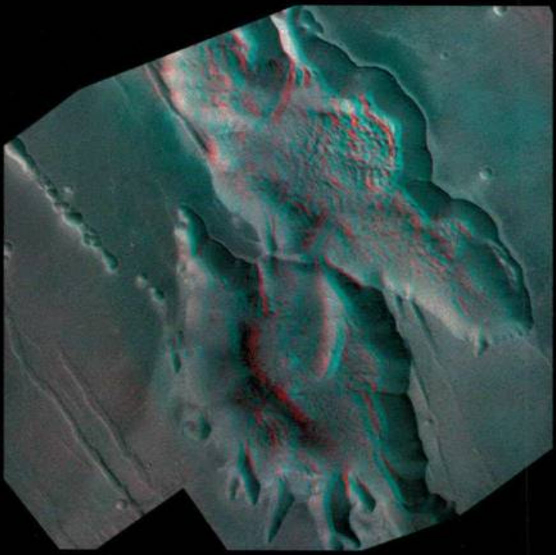
Jeff Hester (Arizona State University), et al., NASA/Scott Kahler

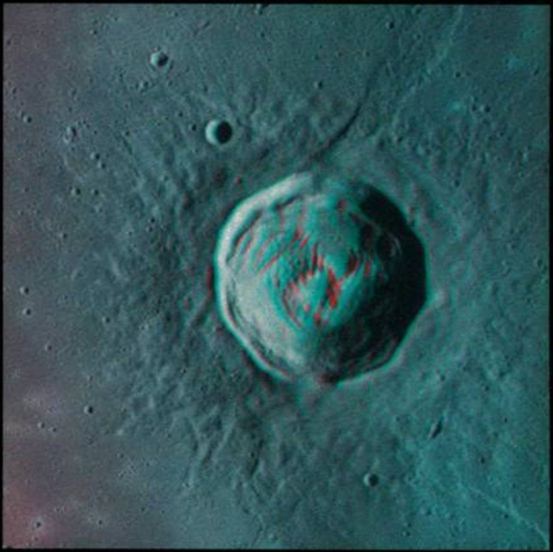


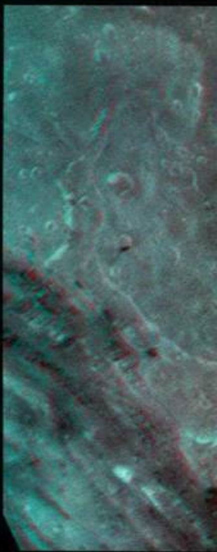
Io: six-mile-high Haemus Montes

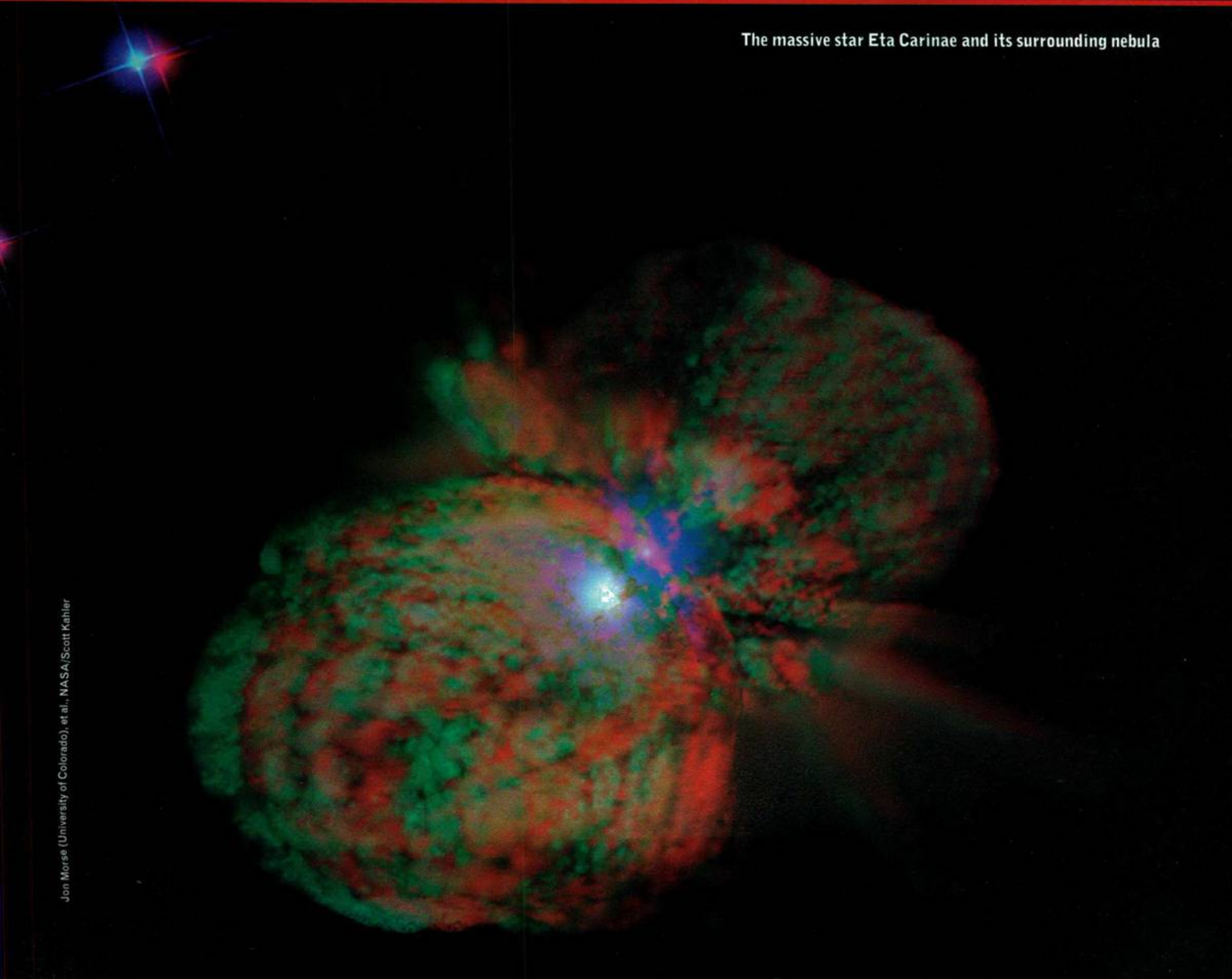


Earth: Klyuchevskaya Volcano on Russia's Kamchatka Peninsula

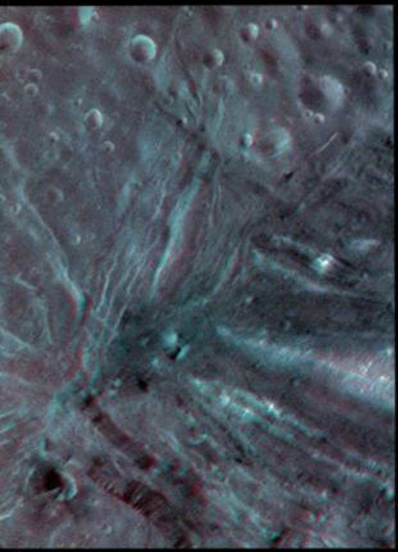

Mars: small section of Valles Marineris


Moon: 19-mile-wide Lambert Crater

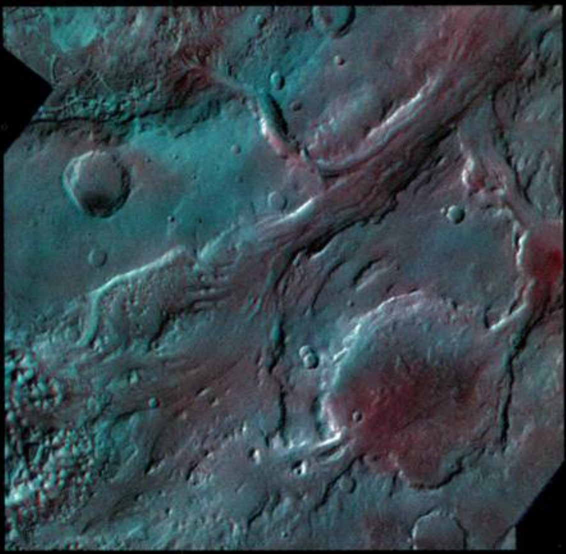



The massive star Eta Carinae and its surrounding nebula

Jon Morse (University of Colorado), et al., NASA/Scott Kahler

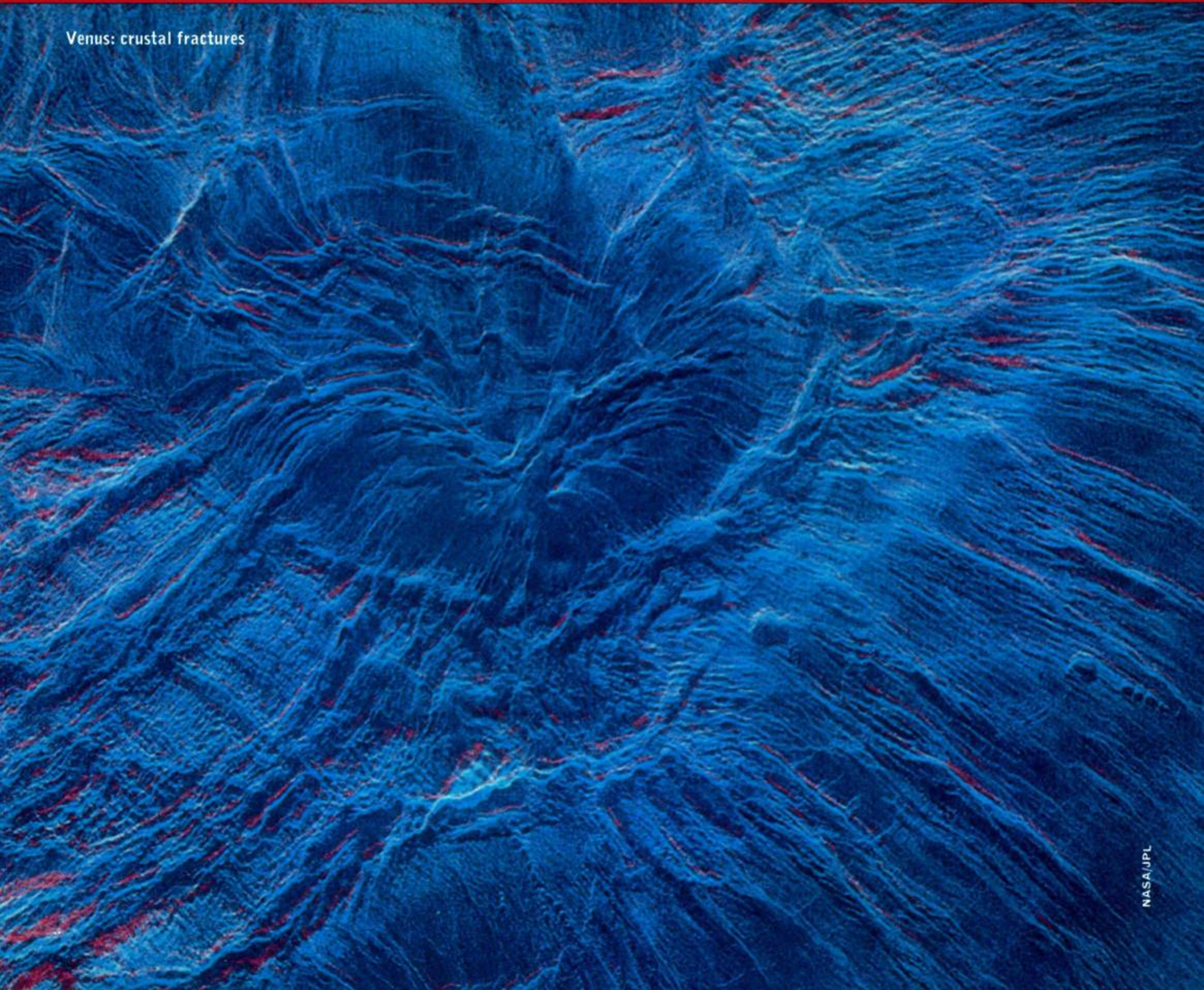


Uranus's moon Miranda



Mars: Iani Chaos, a tributary of Ares Vallis

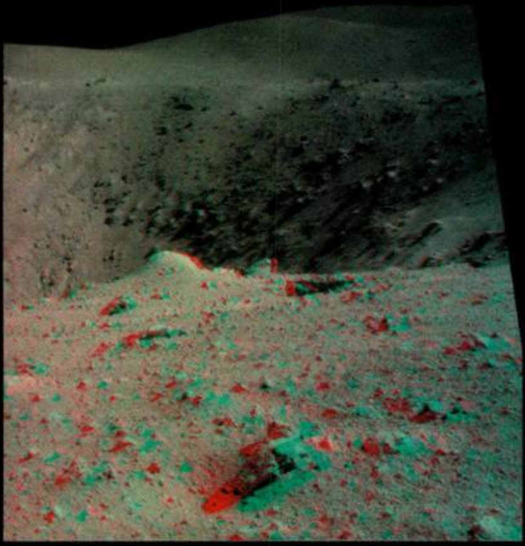
Mars: outflow channel Ma'ad



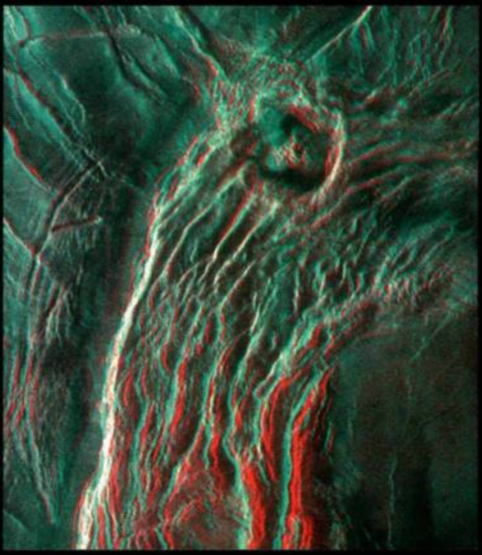
Venus: crustal fractures

NASA/JPL

m Vallis

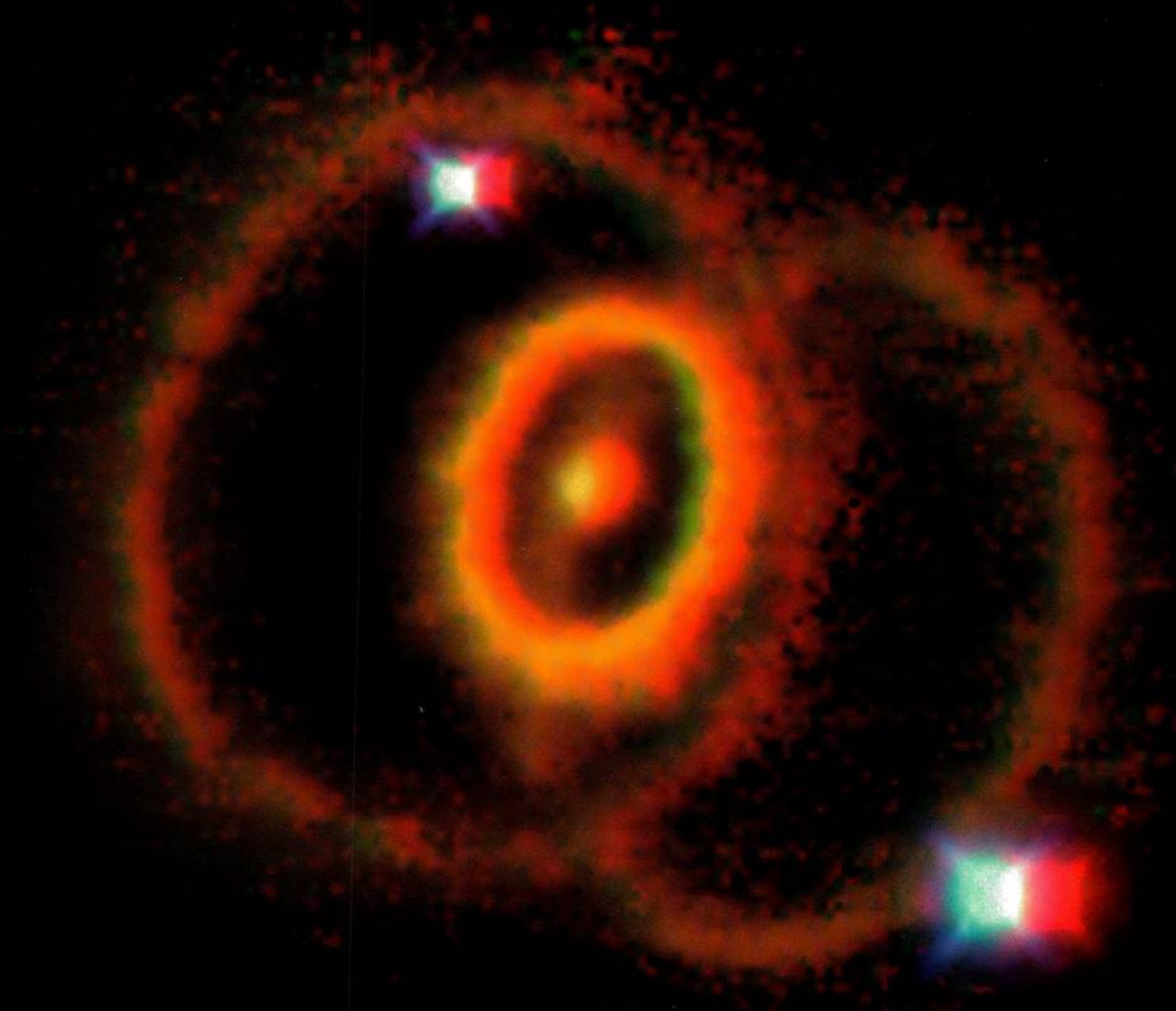


Moon: crater near Apollo 16 landing site



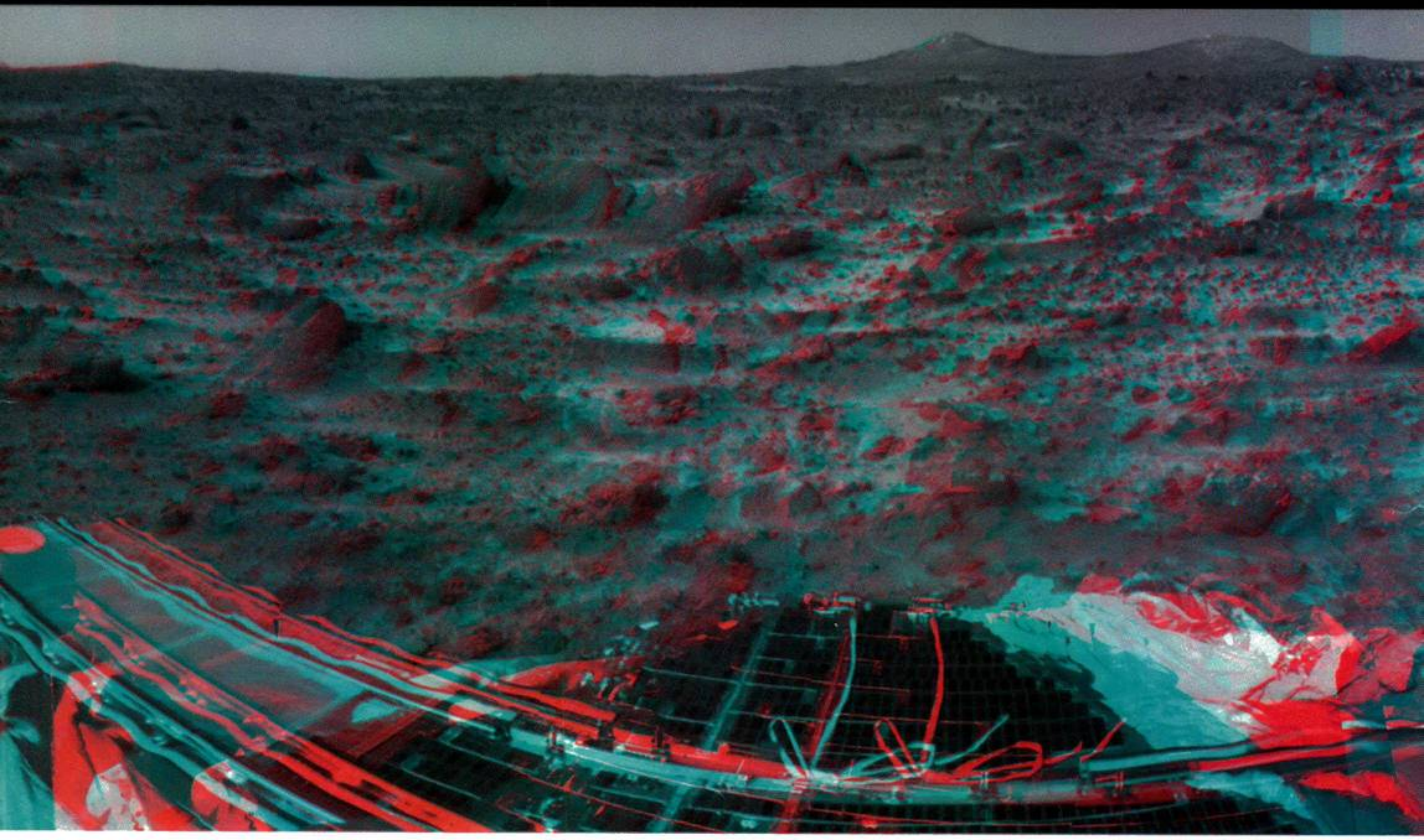
Venus: ridges and 20-mile-wide crater

Three rings surround Supernova 1987A



Chris Burrows (STScI), et al., NASA/Scott Kahler

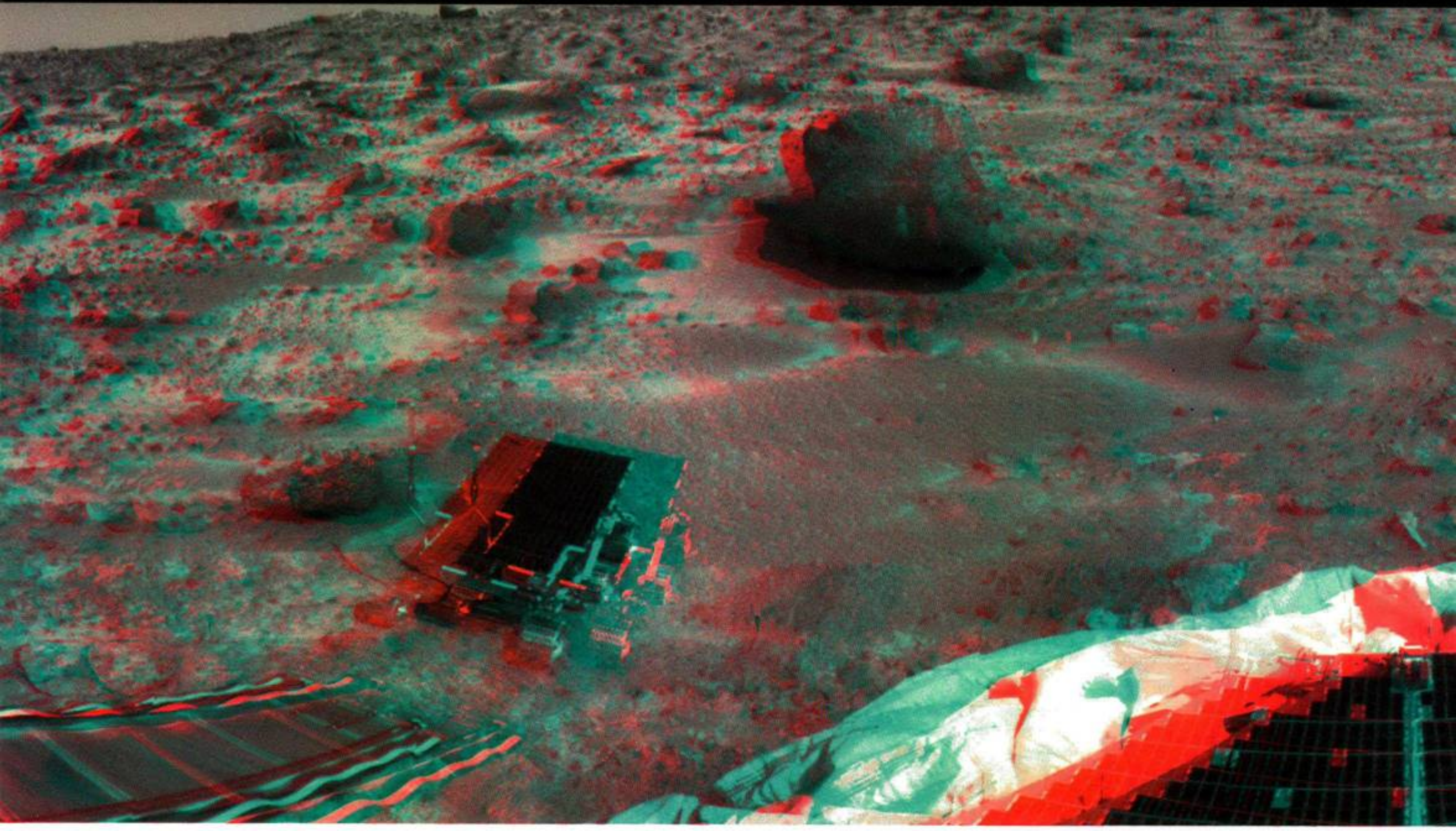
Pathfinder's 3



AS SPACE MISSIONS GO, IT WAS brief. In fact, Pathfinder's exploration of Mars didn't even outlast the 1997 baseball season. The July 4th landing on the Red Planet came just days before the All-Star Game. By the time the World Series was in full swing in late October, the mission was essentially over, the spacecraft silenced by communications problems. But that didn't dim the assessment of Pathfinder's mission: It was a grand slam. For engineers, it proved the spaceworthiness of a new, innovative landing system that featured airbags to cushion the impact on the planet's rock-strewn surface. For NASA, the mission gave a stunning endorsement of administrator Daniel Goldin's "faster, better, cheaper" approach to space exploration. And Pathfinder has provided a flood of data that will keep planetary scientists busy for years and that has already added critical new findings about Mars, both past and present.

At NASA's Jet Propulsion Laboratory, where Pathfinder was designed, built, and controlled, the Independence Day landing brought a wave of jubilation. Scientists and engineers in the Pathfinder mission control room cheered when the first images from the lander (soon renamed the Sagan Memorial Station) appeared on monitors. Even in public they did not hide their joy; at one press briefing they paraded before the television cameras giving each other high fives. And who could blame them? Not only had Pathfinder pulled off a landing many insiders thought was impossible, it had bumped down at a spectacular site for geologic exploration. The landing site, at the mouth of an ancient flood channel called Ares Vallis, showed an enticing variety of features, from rocks and boulders to drifts of sediment to distant peaks. The twin Viking landers had

-D Extravaganza



touched down in 1976; now, 21 years later, the exploration of the martian surface had resumed.

After the Deluge

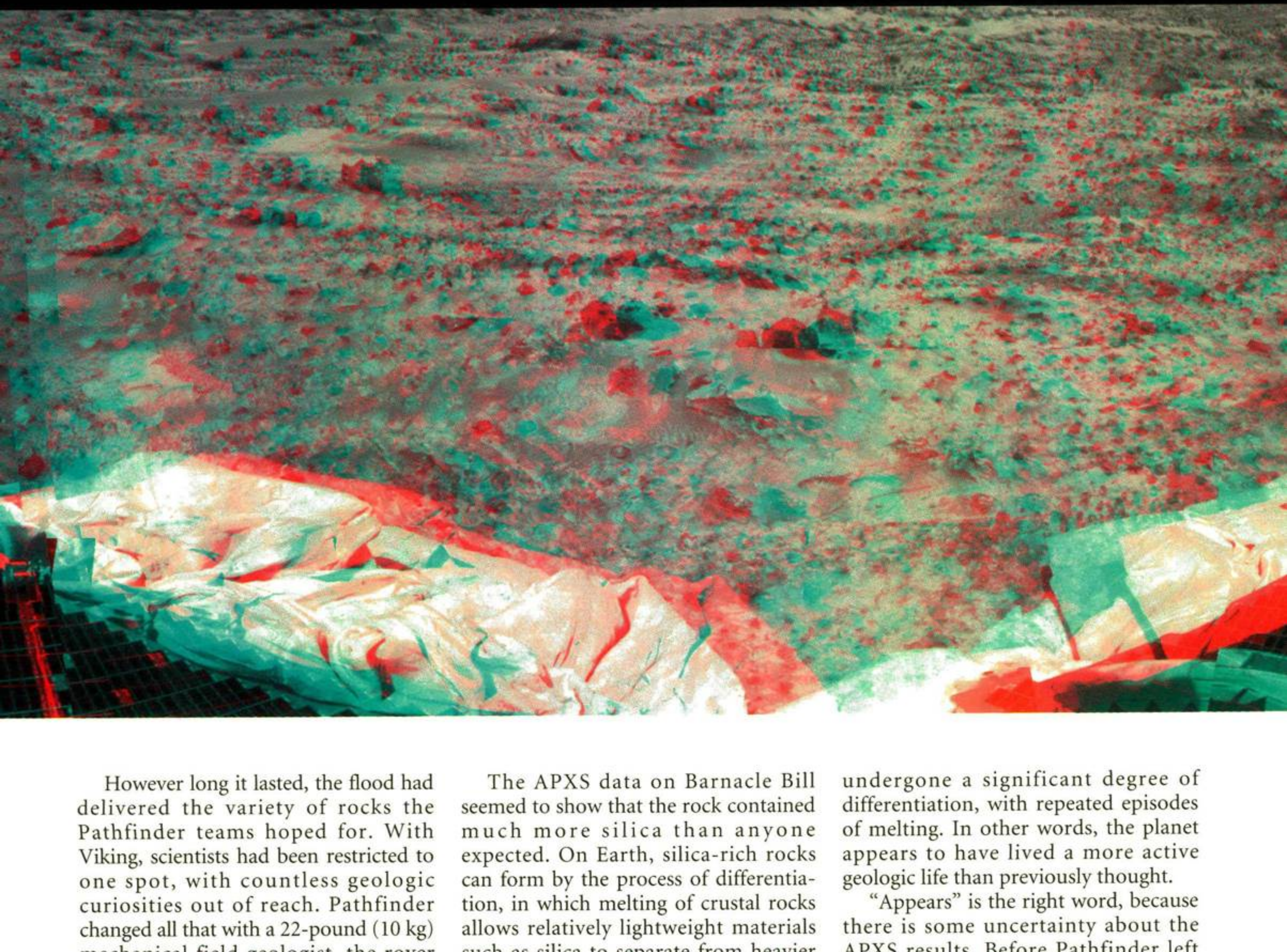
The first pictures from the Pathfinder lander showed a rolling plain strewn with rocks and boulders. Viking never could have landed in a place so rugged, but it was just what the Pathfinder scientists had wanted: Those rocks, they hoped, had been carried there from a wide region of the planet by the flood waters that formed Ares Vallis. If so, they represented clues to a Mars very different from the one we see now. Today, the planet's atmosphere is so thin — exerting a surface pressure only 0.007 times that at sea level on Earth — that water cannot exist in a liquid state. But as scientists studied the lander's panoramic images, they saw evidence almost everywhere they looked that there had once been water on Mars — lots of it.

In an area dubbed the Rock Garden, rocks are stacked against one another like playing cards; resembling ones deposited by terrestrial floods. Stereo images like the one above clearly reveal that the rolling plain was cut by a series of furrows, which were probably carved by giant boulders carried in the deluge. And the erosive action of the flood may explain the rounded shapes of some rocks, including the boulder nicknamed Yogi (for its resemblance to a certain cartoon bear). In all, the images hint that a flood of mind-boggling proportions swept across the landing site sometime between three and four billion years ago.

Pathfinder geologist Michael Malin has studied the effects of gigantic terrestrial floods in such places as Iceland and the northwest United States. "The martian floods," Malin says, "were so much bigger that they strain our ability to understand how water can do this kind of damage." At Ares Vallis, Malin speculates, water may have poured forth at a rate of 100 million cubic meters per second — in which case, the flood may have been over in only a few days.

Now dry and sculpted by winds, the Mars Pathfinder site was once the scene of a rampaging flood.

by Josh Rogan



However long it lasted, the flood had delivered the variety of rocks the Pathfinder teams hoped for. With Viking, scientists had been restricted to one spot, with countless geologic curiosities out of reach. Pathfinder changed all that with a 22-pound (10 kg) mechanical field geologist, the rover Sojourner, which for the first time let scientists roam across the surface of another planet. Sojourner was equipped with an alpha proton x-ray spectrometer (APXS) for making direct measurements of the composition of martian rocks and soil and a pair of cameras for close-up stereo images. The very first rock analyzed, Barnacle Bill, turned out to be the biggest surprise of the mission.

The APXS data on Barnacle Bill seemed to show that the rock contained much more silica than anyone expected. On Earth, silica-rich rocks can form by the process of differentiation, in which melting of crustal rocks allows relatively lightweight materials such as silica to separate from heavier ones, such as iron and magnesium. Barnacle Bill is evidence that Mars has undergone a significant degree of differentiation, with repeated episodes of melting. In other words, the planet appears to have lived a more active geologic life than previously thought.

"Appears" is the right word, because there is some uncertainty about the APXS results. Before Pathfinder left Earth, the instrument was not fully calibrated under martian atmospheric

NASA produces 3-D images for more than just the gee-whiz effect. Scientists are studying this panorama to discern subtle topographical features that can help them reconstruct the site's history. In particular, 3-D images show that the area is much more scarred than was evident from normal 2-D images. Evidence for massive flooding include undulating terrain and deep furrows that were probably carved by boulders carried in a deluge. The Twin Peaks lie less than one mile to the west. Barnacle Bill is just to the left of the microwave-oven-size rover Sojourner. The tilted boulders of the Rock Garden lie near the left edge. All images: NASA/JPL

Beneath the Surface

For all the fascinating data on the martian surface radioed back by Pathfinder, scientists would like to know what lies beneath the surface. Planetary scientists have long suspected that Mars's crust overlies a dense rock layer called the mantle, with an even denser, metal-rich core at the planet's center. But they've had no direct means of exploring the interior. Pathfinder's radio signals have given scientists new clues about the existence and size of the martian core.

Scientists already knew the diameter and total mass of the planet, which is about half the size of Earth. Using Pathfinder's radio signals, a team led by JPL's William Folkner has established a third parameter, the planet's moment of inertia, which relates to how mass is distributed throughout the planet. To do this, Folkner's team monitored Doppler shifts in the frequency of Pathfinder's radio signals caused by changes in the distance between Earth and Mars. The shifts tell the scientists about subtle changes in the orientation of Mars's axis of rotation. These changes, in turn, give clues to the nature of the planet's interior. Folkner's team also compared their data with observations of the radio signals from the Viking landers.

The results, says Folkner, have allowed his team to calculate the moment of inertia, and that has given them an estimate of the size of the planet's core. They assume that the core is very dense — composed of solid iron — and that the mantle is similar in composition to martian meteorites discovered on Earth. If so, then Mars's core must have a minimum diameter of about 1,600 miles (2,600 km). If the core is less dense (for example, a mixture of iron and sulfur), then it is probably no wider than 2,500 miles (4,000 km).

Folkner's team had hoped to refine its calculations by monitoring Pathfinder's radio signals over the coming months, but those plans were put aside when contact with the spacecraft was lost. Team members will have to wait for future landers to resume their efforts. In the meantime, Pathfinder's orbiting colleague, Mars Global Surveyor, has discovered a weak magnetic field — further evidence that Mars once had, or may still have, a fluid core.

conditions. As a result, only the x-ray portions of the data have been usable; scientists have been unable to use the alpha particle and proton signatures. Without them, Pathfinder scientists have no census of relatively light elements such as oxygen, a key geologic ingredient. JPL's Joy Crisp says these data will eventually be useable but that "it just requires many months of calibration." However, she adds, "It means that we aren't sure" about the high silica content in Barnacle Bill. University of Arizona geologist Ronald Greeley is more confident. Despite the problems with the APXS data, he says, "I think the high silica content is still extremely important, and valid."

Other rocks analyzed by Sojourner have less silica, suggesting that they cooled from lava of different composition — if the rocks are indeed volcanic. The APXS data cannot distinguish between volcanic rocks and rocks composed of sediments, or those blasted out of nearby impact craters. To make such distinctions, scientists have scrutinized the pictures from the lander and the close-ups from Sojourner. The U.S. Geological Survey's Henry Moore has done this, and he has identified rounded pebbles which may have acquired their shape while being transported in floods, or perhaps, he says, by wave action on an ancient martian beach. He cautions that there may be other possible interpretations — the pebbles could be bits of glass formed by the heat of a meteorite impact, or they may have formed in volcanic eruptions.

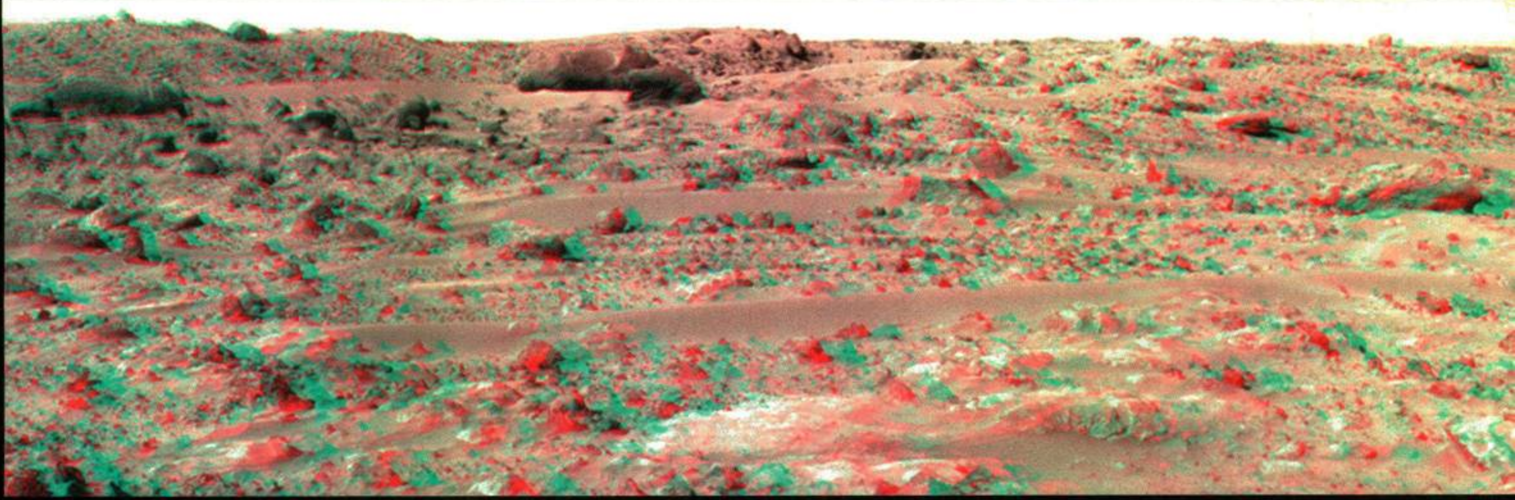
Near one pebble is a rock called Lamb that may have been its source. Another rock has hollows on its surface that may once have contained rounded pebbles. To Moore, these are signs that rocks called conglomerates, formed from amalgams of smaller rocks and mud, exist on Mars. "These conglomerates," Moore explains, "may be ancient sedimentary rocks that were deposited from previous streams and floods." Elsewhere, Moore finds rocks that appear to have cooled from once-molten lava. He adds, "It's going to take a long time to sort out all the things we're seeing. But things are really looking interesting and exciting."

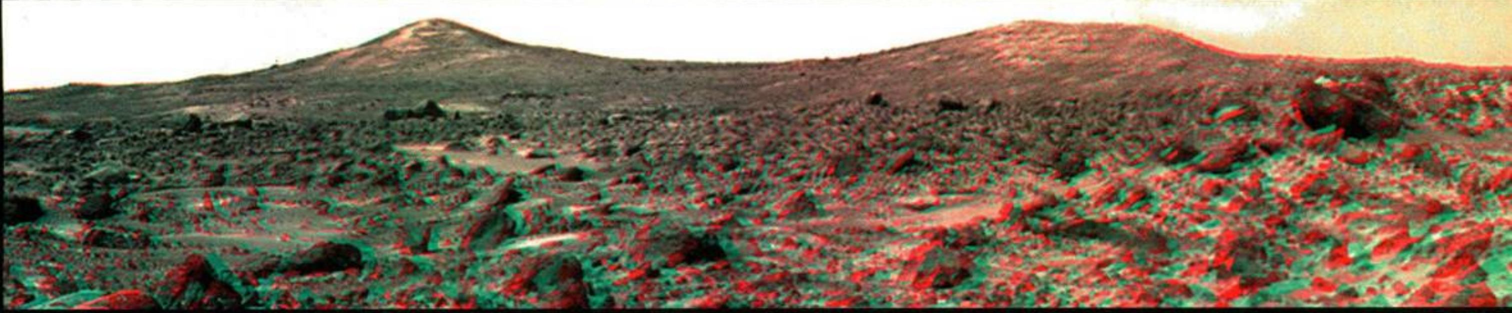
Dust in the Wind

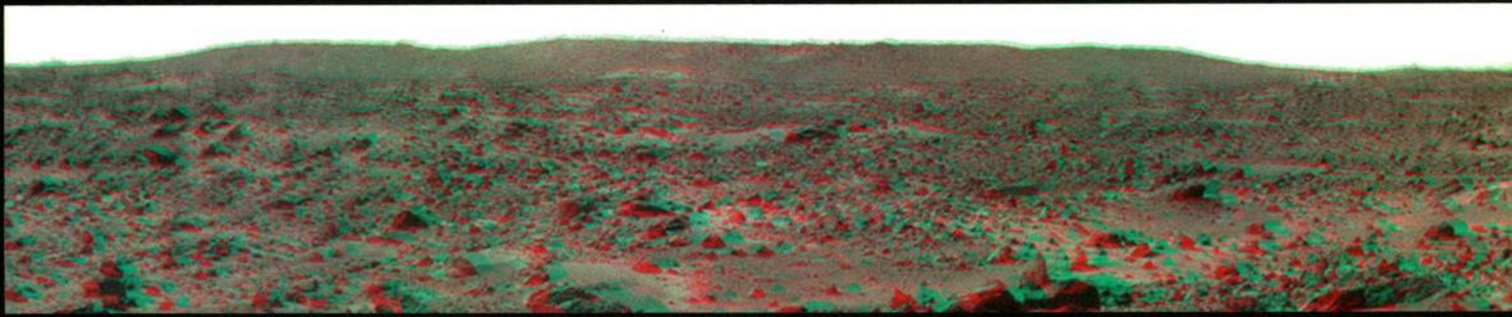
One puzzling aspect of the APXS results came in the form of higher percentages of sulfur than expected. In this case, says Crisp, the explanation may be the ubiquitous martian dust. "We see dust on these rocks, and we know the dust is rich in sulfur," she says, "so some or all of that sulfur is probably from the dust." Crisp finds herself wishing that Sojourner had been equipped with some means of cleaning off a rock before analyzing it. "Even a brush would have helped," she notes. So would a magnifying lens, adds Crisp, noting that even Sojourner's close-up images are not detailed enough to pin down the identifications of the rocks. These are improvements that will have to be left for future spacecraft.

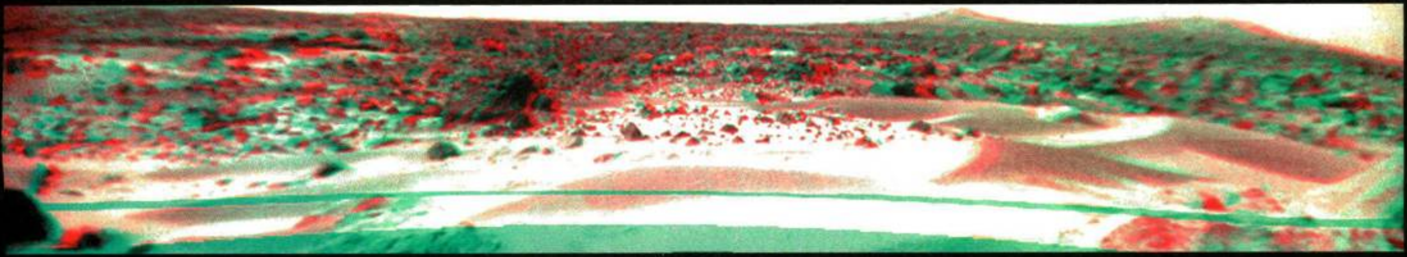
The martian dust, however, has its own story to tell. Several times Sojourner was directed to analyze patches of soil, which, based on the rover's cleat marks left in the soil, seems to have the consistency of baking flour. The results showed compositions similar to those at the Viking landing sites. That tends to confirm the long-held theory that martian dust is nearly the same everywhere on the planet, having been distributed by the global winds.

While Sojourner was analyzing dust on the surface, the lander's cameras were studying dust in the atmosphere. The Vikings had arrived on Mars at a time when airborne dust was fairly abundant, but some scientists had







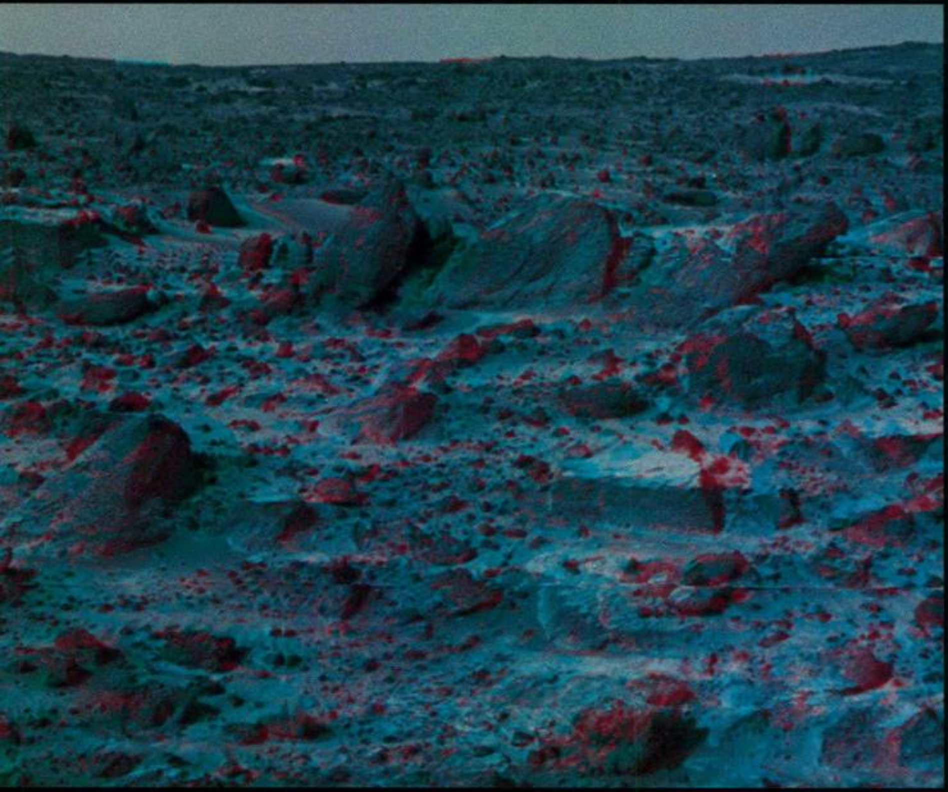


TOP TO BOTTOM: The Pathfinder team assembled this 3-D image of the eastern horizon. Shifting sand dunes lie in the foreground. The large, elongated rock left of center is known as Zaphod, which is about 115 feet (35 meters) away. The rock in front of Zaphod is named Indiana Jones.

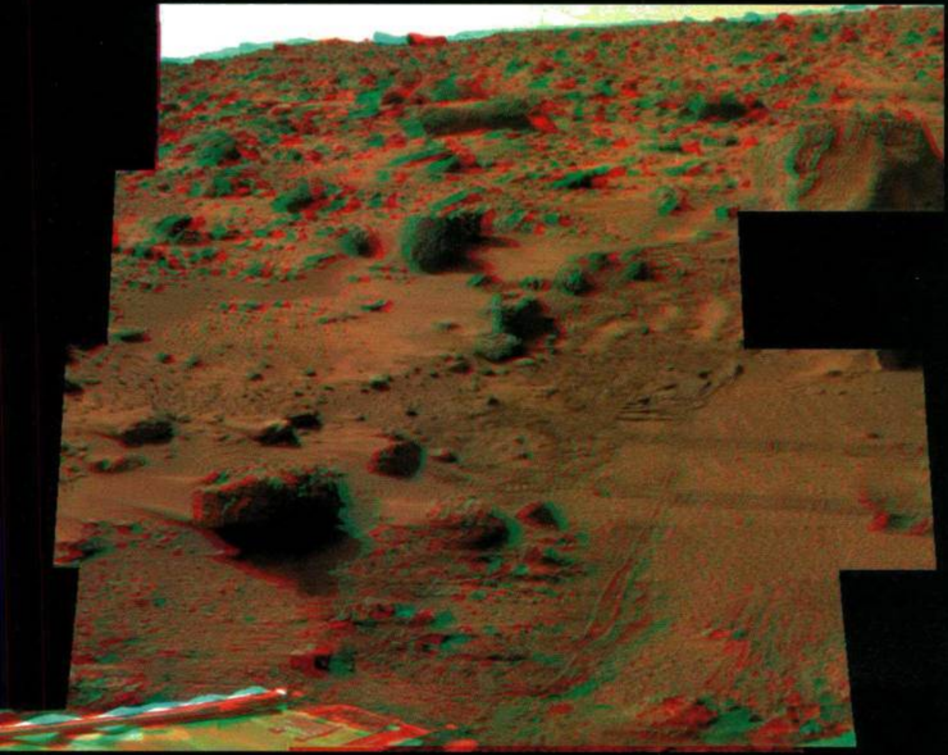
The Twin Peaks rise 100 feet (30 meters) above Ares Vallis. The North Twin (right) lies 0.53 mile (0.86 km) to the west of the lander, while the South Twin lies 0.63 mile (1 km) away. Many of the foreground rocks were deposited by a massive flood. The boulder near the right edge is Hippo; it's three feet (one meter) wide and 80 feet (25 meters) away. The white streaks on the South Twin have been dubbed the Ski Run; they might have been formed by running water.

The raised rim of Big Crater (center) lies 1.4 miles (2.2 km) toward the southern horizon. Despite its name, Big Crater is rather small by martian standards — about 0.9 mile (1.5 km) across. To the right of the crater and 19 miles (30 km) in the distance, and somewhat obscured by haze, is 1,480-foot-high (450 meters) Far Knob. Just to the left of Big Crater is a tiny triangle sticking up above the horizon; that's Southeast Knob, 13 miles (21 km) from the lander.

The rover ventured behind the Rock Garden to peer into a swale that was not visible to the lander's cameras. This image shows light-colored dunes that look just like their terrestrial, quartz-rich counterparts. The Twin Peaks lie to the right (almost due west).



ABOVE: The rover's APXS instrument analyzed the chemical composition of many of these rocks in the Rock Garden. From left to right, the five most prominent rocks are Shark, Half Dome, Moe, Pumpkin (behind Moe), and Stimpy (in front of Moe). In the foreground, Wedge is at the lower left and four-inch-high Flat Top is just to the right of center. Frog is at the far right, slightly behind and to the right of Stimpy. The Rock Garden members are stacked together like pancakes; they were almost certainly deposited in a massive flood. **BELOW:** This image shows the mysterious dark boulder appropriately named Couch, roughly 200 feet (60 meters) to the west-northwest of the lander.



predicted that Pathfinder would find a clearer, less dusty atmosphere. That had also been suggested by recent Hubble Space Telescope images of Mars. The lander's first images dispelled that notion: The sky was bright, as it had been during Viking, due to sunlight being scattered by countless dust particles suspended in the atmosphere.

Data from the lander's meteorology sensors may have solved the riddle of what makes martian dust airborne. Once aloft, says Ron Greeley, dust particles easily remain airborne. The problem is raising the tiny grains off the surface to begin with. Calculations show that wind speeds would have to be higher than the gentle breezes generally seen on Mars. But there is another answer: dust devils. "We've speculated for years that dust devils are one mechanism for raising dust into the atmosphere," says Greeley. That idea now appears to be confirmed. On several occasions, a dust devil passed over the lander, causing a sudden fluctuation in temperature and pressure. The lander has also shown that atmospheric conditions within a few feet of the surface can undergo strong variations in a matter of seconds. To Greeley, this kind of instability increases the likelihood that dust will be raised.

Some dust does fall back to the ground, and that gave Pathfinder an opportunity to investigate its composition. A set of magnets of varying strength attached to the lander was monitored for changes; over time they collected bits of airborne dust. This confirmed the Viking finding that the dust contains magnetic material. So far, Crisp says, the best guess for the magnetic component is an iron oxide called maghemite, which forms in water-rich environments on Earth. Surprisingly, the results also indicate that every individual dust grain — each of which is estimated at no more than a micron in size — is actually a composite of several minerals. "That's in *one micron*," notes Crisp. How would such tiny amalgams have been produced? One way, she says, is precipitation from pools of water. Even the tiniest grains of dust seem to testify to Mars's watery past.

But Mars today could not be more different. With no liquid water, says U.S. Geological Survey researcher Wes Ward, "Wind is probably the dominant agent shaping the martian surface at this moment." And there is ample evidence of this in Pathfinder's images. Windblown dust has formed dune-like deposits, as well as dust "tails" in the lee of rocks and boulders. And some of the boulders viewed by Sojourner's close-up camera are covered with elongated pits, giving them a close resemblance to wind-sculpted rocks in terrestrial deserts.

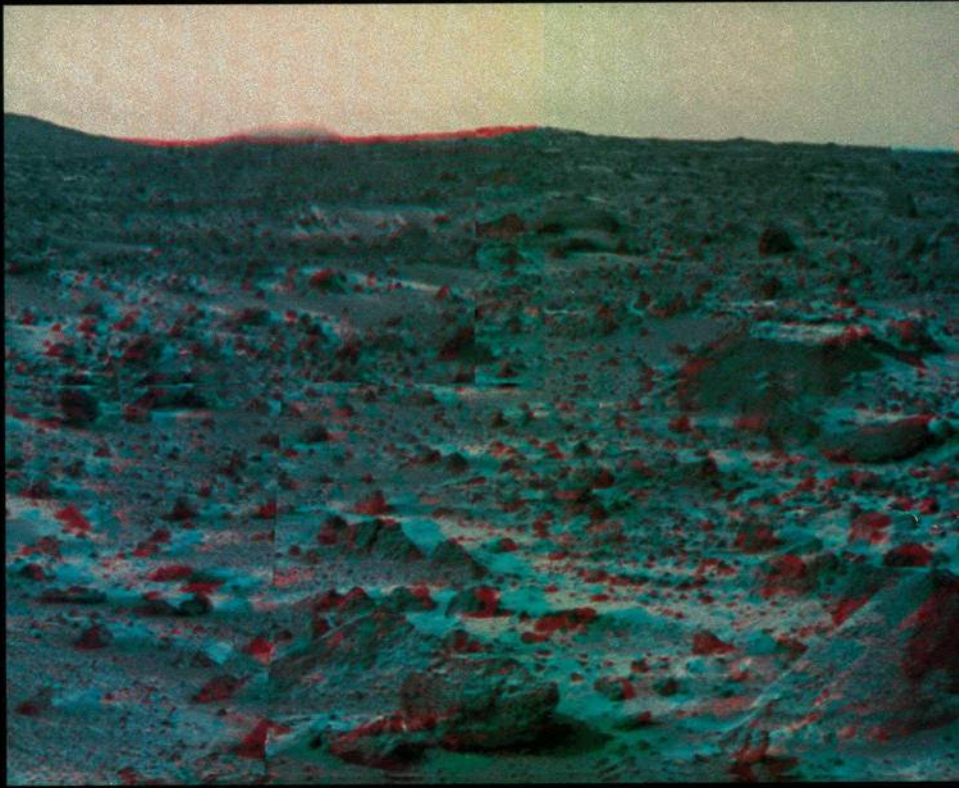
Communication Breakdown

Greeley and his colleagues had been looking forward to more data on the martian winds. And they had hoped Pathfinder's cameras would continue to send back pictures during the martian fall and winter, to document changes in the surface. By late September the meteorology sensors had been recording higher pressures, a harbinger of the approaching dust storm season. And the lander was continuing to send down portions of a "Super Pan," a panoramic view at full resolution, in 12 wavelengths, and in stereo.

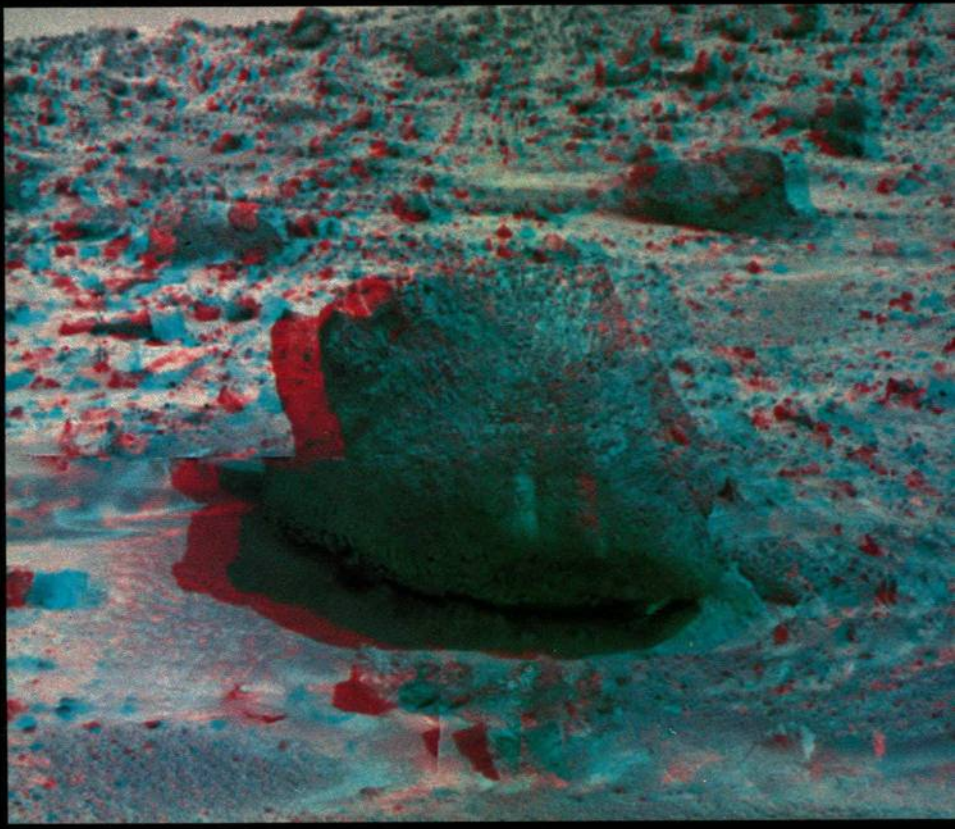
Then, after Pathfinder and Sojourner had spent almost three months on Mars, JPL lost contact with the spacecraft. Problems with the lander's battery may have allowed the transmitter electronics to fall prey to the martian cold. At this writing, subsequent efforts to reestablish the radio link have proved unsuccessful. "We've done everything that's reasonable, everything that we can expect to do," says Mars Pathfinder project manager Brian Muirhead of JPL. Even so, controllers will continue on a limited basis to try to reestablish contact.

"We actually predicted something like this would happen, back at the beginning of the extended mission," explains Muirhead. He confesses to "a sense of loss, of not being able to say a proper good-bye" to Pathfinder. But he adds, "That's part of the price of doing business in deep space." And even though the mission's end leaves some tasks unfinished, Muirhead is more than happy about what has already been accomplished — including solving the many technical difficulties of building Pathfinder on a very limited budget. "We're ecstatic about what we've been able to do, technologically, programmatically — getting this job done in budget and on time — and scientifically. It's way beyond anything we ever hoped for." ▣

Science writer Josh Rogan wrote the cover story "Bound for the Ringed Planet" for the November 1997 issue of Astronomy.



ABOVE: The prominent rock Wedge lies at the lower right. The large rock above Wedge is named Chimp. The pointed hill in the far distance is Far Knob, 19 miles (30 km) away to the south. **BELOW:** The second rock analyzed by the rover's APXS instrument was Yogi. This three-foot-wide boulder appears to be a basalt, the most common volcanic rock on Earth and in the inner solar system. In general, the martian rocks analyzed by APXS were more like their terrestrial counterparts than scientists had anticipated.



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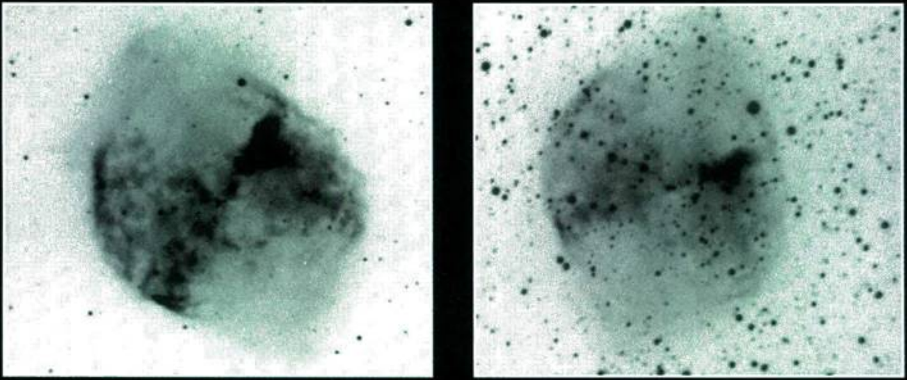

M27 Planetary Nebula. The large apparent size of this nebula classes it as probably one of the nearest of the planetaries at a probable distance of about 850 light years and about 2 1/2 light years in diameter. The central star, of magnitude 13.5, has about 1/2 the solar luminosity, if the adopted distance is reasonably correct. As in all planetary nebulae, the faint central star is an abnormally hot bluish dwarf or sub-dwarf with a spectrum resembling that of an ancient nova and a calculated surface temperature of about 85,000 deg. K, one of the hottest stars known. It is assumed that planetaries are formed by ejection of material from the hot central star, but the exact details of the process are unknown. ***The left image*** is a narrow band 3600 second CCD image taken with a Model ST-7 CCD Imaging Camera through an Ha filter. *Courtesy Benoit Schillings*. ***The right image*** is a 1200 second ST-7 CCD image taken through a 7", f/7 Astrophysics refractor. Both images utilized the self guiding mode. *Courtesy Tony Hallas*.

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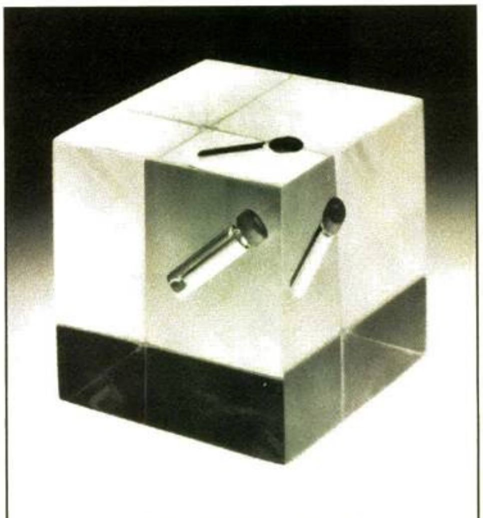

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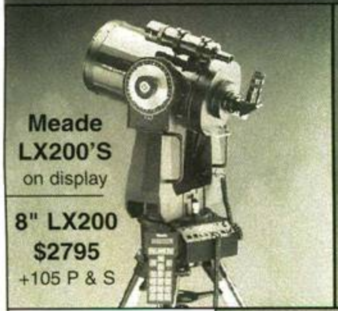

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WRITE NO. 4 ON THE READER SERVICE CARD

THE SKY SHOW

March. In like a lion and out like a lamb? Say goodbye to winter and its bright constellations as we usher in the stars of spring. By Martin Ratcliffe and Alister Ling

▶ March begins with **Saturn** shining brightly at magnitude 0.7 in Pisces the Fish. It stands as a lonely evening sentinel, keeping watch over the more elusive **Mars** and **Mercury**. Take time early in the month to observe Saturn, for it will be heading into the glare of evening twilight by month's end. Already hovering in the yellowish-orange remnants of the sun is magnitude 1.2 Mars. It's dimmer than Saturn and will probably be twinkling rapidly.

The messenger Mercury is climbing higher in the western sky, preparing for its March 11 rendezvous with Mars. During the first week of the month, Mercury shines at a dominant magnitude –1.4, making it easier to spot than the Red Planet. This gives you the rare chance to use elusive Mercury as a guide in finding Mars.

Each night Mercury appears higher in the sky, passing only a degree from Mars on March 11. Mercury then reaches its greatest elongation (19°) east of the sun on March 19. This places the planet in dark skies an hour or so after sunset. During this same period, Mercury passes a few degrees beneath Saturn. It then rises to the same altitude above the horizon as the ringed planet, with just 5° separating the pair on March 21.

Lucky viewers may also catch a glimpse of fading Mars. On the same day, the Red Planet forms a triangle with Mercury and Saturn. The triangle aims down toward the western horizon, with Mars marking its point, while Mercury and Saturn form the base.

Saturn and Mars continue their plunge into the solar glare during the remainder of the month. Watch the passage of a slender lunar crescent close to Saturn on March 29. Mercury's path has looped back to join them, lying to the upper right of the moon on

As winter's icy grip begins to relinquish its hold, the warm winds of spring usher in a new observing season. Soon the spring galaxies will be in prime position. Until then, enjoy the bright stars and fading planets in the March sky.

Dennis Mammana

MARCH 1998

1 The moon passes 1.0° south of Saturn, 4 a.m. EST

4 The moon passes 0.2° north of Aldebaran, 7 p.m. EST (page 77)

5 First quarter moon is at 3:41 a.m. EST

7 Venus passes 4° north of Neptune, 5 a.m. EST

11 Mercury passes 1.2° north of Mars, 10 a.m. EST (page 76)

12 Full moon is at 11:34 p.m. EST

14 The moon is at apogee (252,394 miles from Earth), 7:39 p.m. EST

19 Venus passes 3° north of Uranus, 2 a.m. EST
Asteroid Juno is at opposition, 4 a.m. EST
Mercury is at greatest eastern elongation (19°), 11 p.m. EST

20 Vernal equinox is at 2:55 p.m. EST

21 Last quarter moon is at 2:38 a.m. EST

23 The moon passes 3° north of Neptune, noon EST

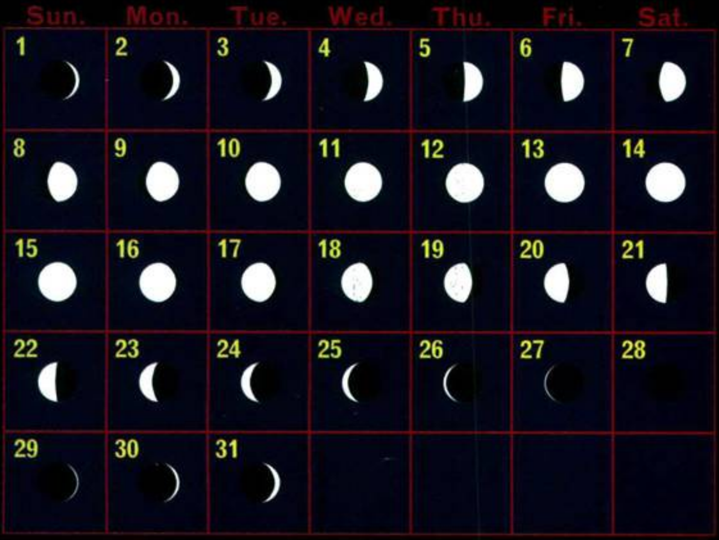
24 The moon passes 3° north of Uranus, 5 a.m. EST
The moon passes 0.09° north of Venus, 2 p.m. EST (page 79)

26 The moon passes 0.8° north of Jupiter, 7 a.m. EST (page 79)

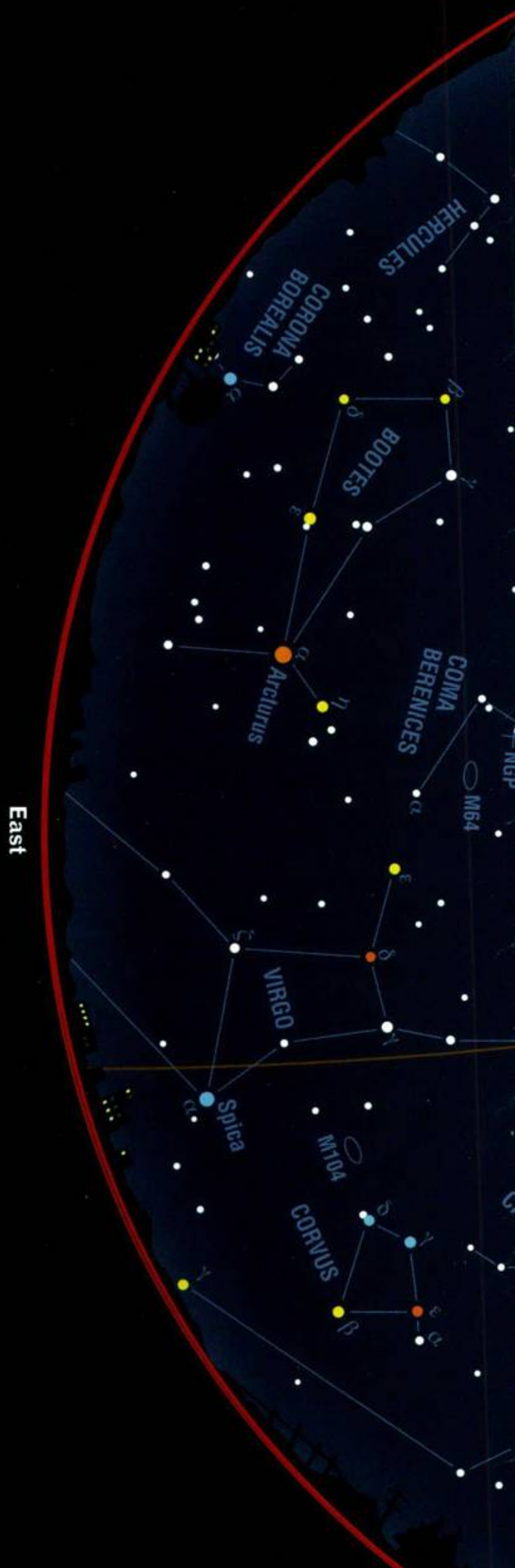
27 Venus is at greatest western elongation (47°), 2 p.m. EST
New moon is at 10:14 p.m. EST

28 The moon is at perigee (221,845 miles from Earth), 2:05 a.m. EST

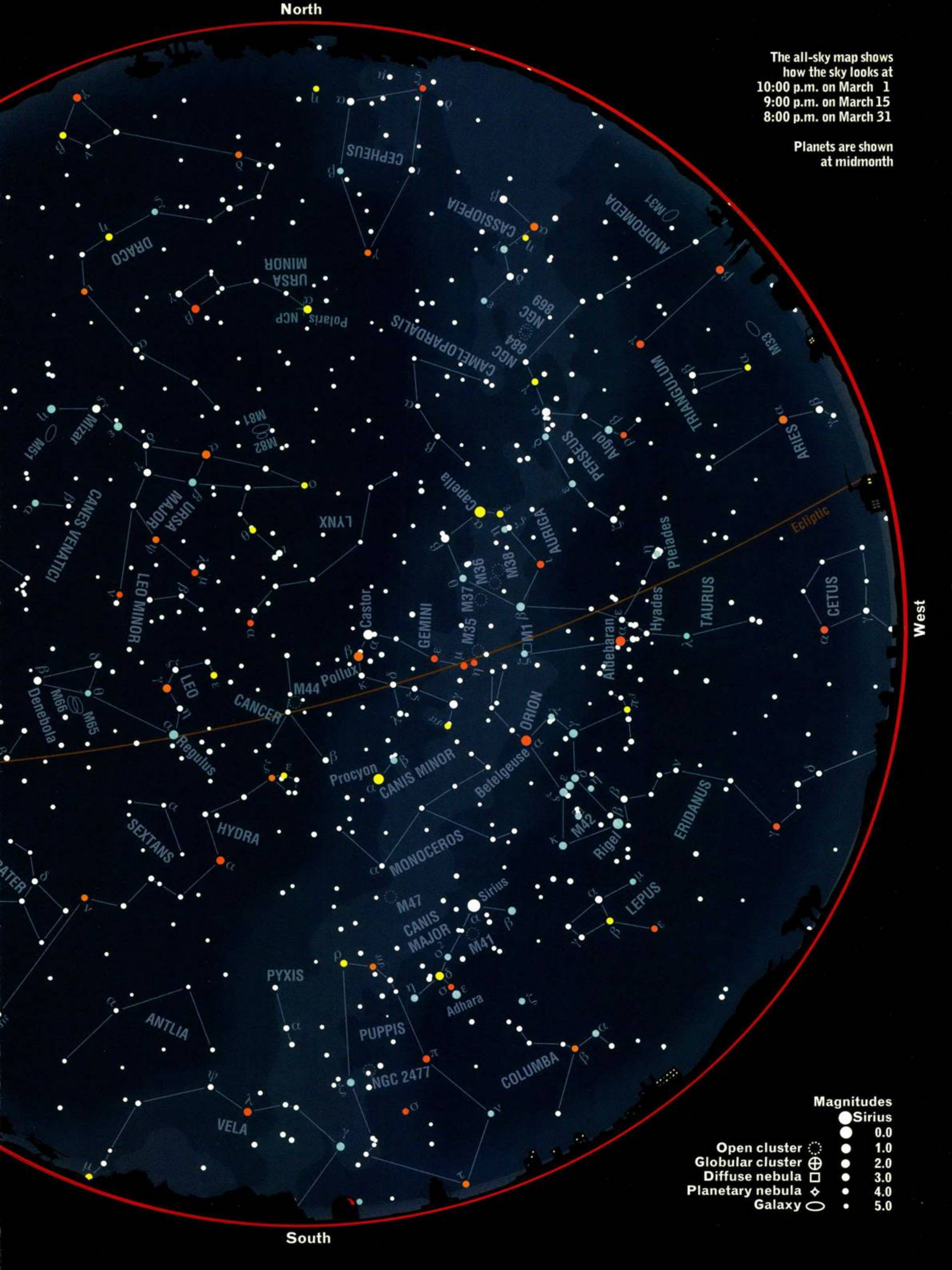
29 Mercury passes 4° north of Mars, midnight EST



Sun.	Mon.	Tue.	Wed.	Thu.	Fri.	Sat.
1	2	3	4	5	6	7
8	9	10	11	12	13	14
15	16	17	18	19	20	21
22	23	24	25	26	27	28
29	30	31				



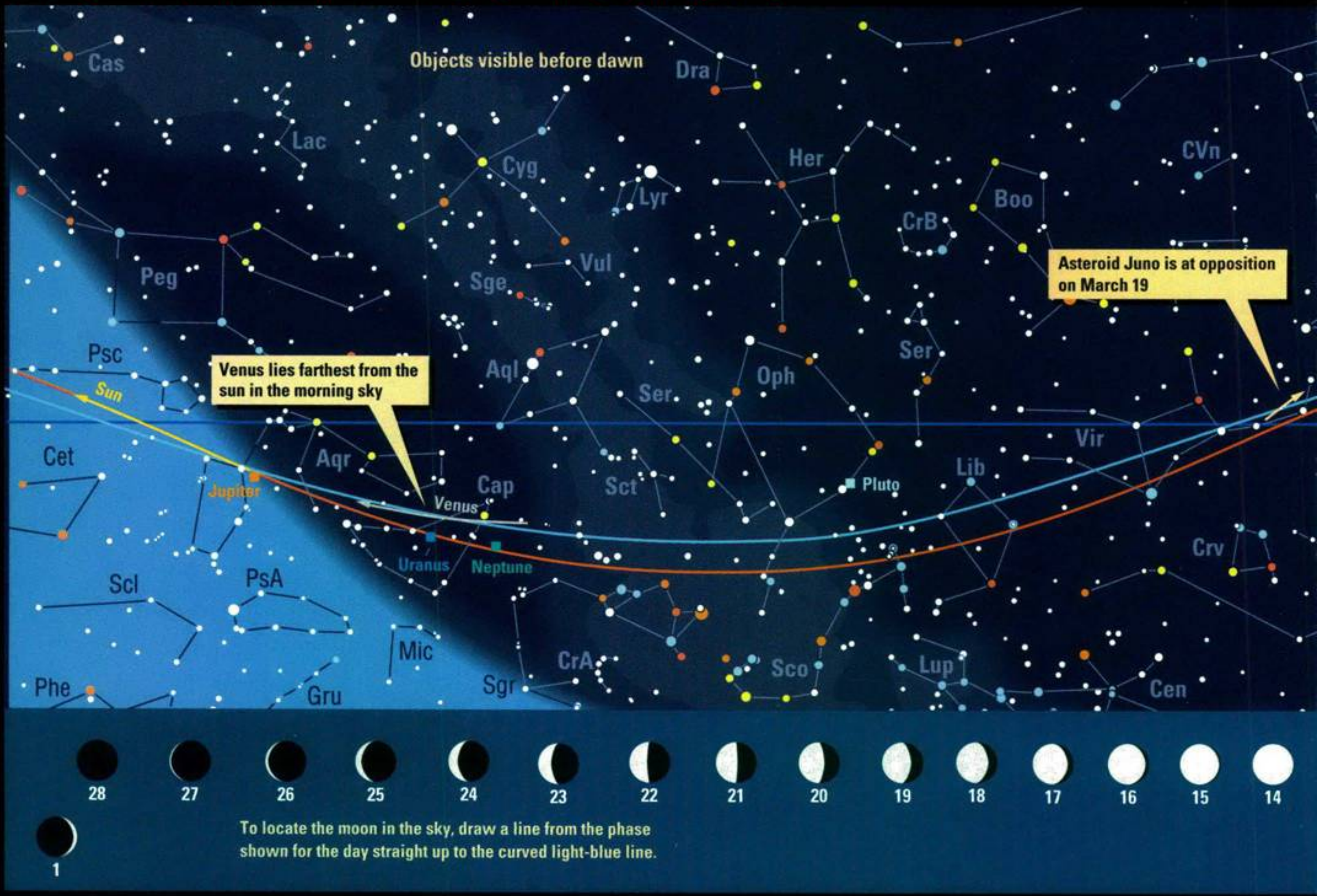
This map portrays the sky at times shown in the upper right corner of the page. Located just outside the map are the four directions: north, south, east, and west. To find stars above your horizon, hold the map overhead and orient it so a direction label matches the direction you're facing. The stars above the map's horizon now match what's in the sky.


North
South
West
CEPHEUS
CASSIOPEIA
ANDROMEDA
M31
DRACO
URSA MINOR
Polaris NCP
CAMELOPARDALIS
NGC 869
NGC 884
M33
TRIANGULUM
ARIES
PERSEUS
Algol
M81
M82
M51
Mizar
URSA MAJOR
CANES VENATICI
LYNX
Capella
AURIGA
M36
M38
M37
Pleiades
Ecliptic
CETUS
TAURUS
Hyades
Aldebaran
M1
M35
GEMINI
Castor
Pollux
LEO MINOR
LEO
M44
CANCER
Denebola
M66
M65
Regulus
ORION
Betelgeuse
Procyon
CANIS MINOR
M42
Rigel
ERIDANUS
SEXTANS
HYDRA
MONOCEROS
CRATER
LEPUS
M47
Sirius
CANIS MAJOR
M41
PYXIS
Adhara
ANTLIA
PUPPIS
COLUMBA
NGC 2477
VELA
Magnitudes
Sirius
0.0
1.0
2.0
3.0
4.0
5.0
Open cluster
Globular cluster
Diffuse nebula
Planetary nebula
Galaxy

The all-sky map shows
how the sky looks at
10:00 p.m. on March 1
9:00 p.m. on March 15
8:00 p.m. on March 31

Planets are shown
at midmonth

THE PATH OF THE PLANETS


Objects visible before dawn
Cas
Lac
Cyg
Lyr
Dra
Her
CVn
Boo
CrB
Peg
Sge
Vul
Psc
Sun
Aql
Ser
Oph
Ser
Cet
Aqr
Jupiter
Cap
Venus
Sct
Pluto
Lib
Vir
Uranus
Neptune
Crv
Scl
PsA
Mic
CrA
Sco
Lup
Cen
Phe
Gru
Sgr
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15
14
1

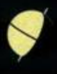
Venus lies farthest from the sun in the morning sky

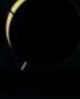
Asteroid Juno is at opposition on March 19

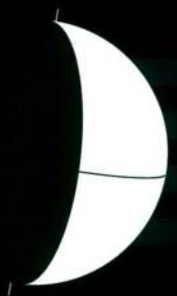
To locate the moon in the sky, draw a line from the phase shown for the day straight up to the curved light-blue line.

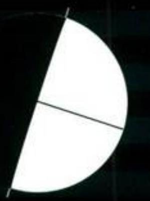
10"

PLANETS	MERCURY	MERCURY	VENUS	VENUS	M
Date	March 15	March 31	March 1	March 31	
Magnitude	−0.8	2.7	−4.6	−4.4	
Angular Size	6.4"	10.2"	35.1"	23.7"	
Illumination	65%	7%	33%	51%	
Distance (AU) from Earth	1.044	0.660	0.475	0.705	
Distance (AU) from Sun	0.308	0.375	0.721	0.724	
Right Ascension (2000.0)	0h39.8m	1h12.2m	19h54.0m	21h42.2m	2
Declination (2000.0)	5°35'	11°17'	−15°56'	−12°25'	

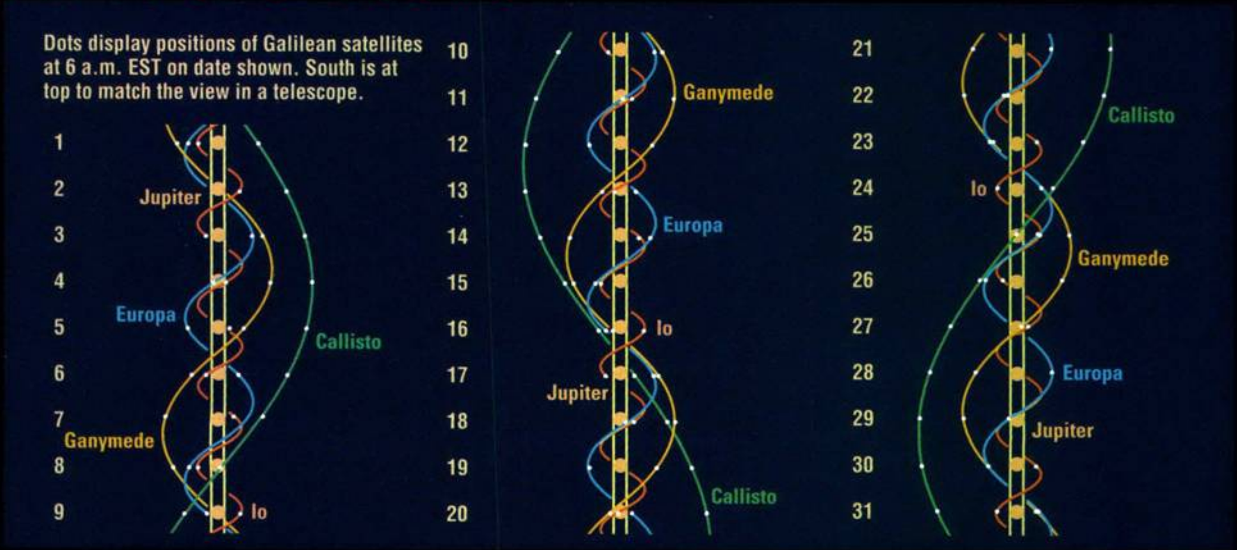




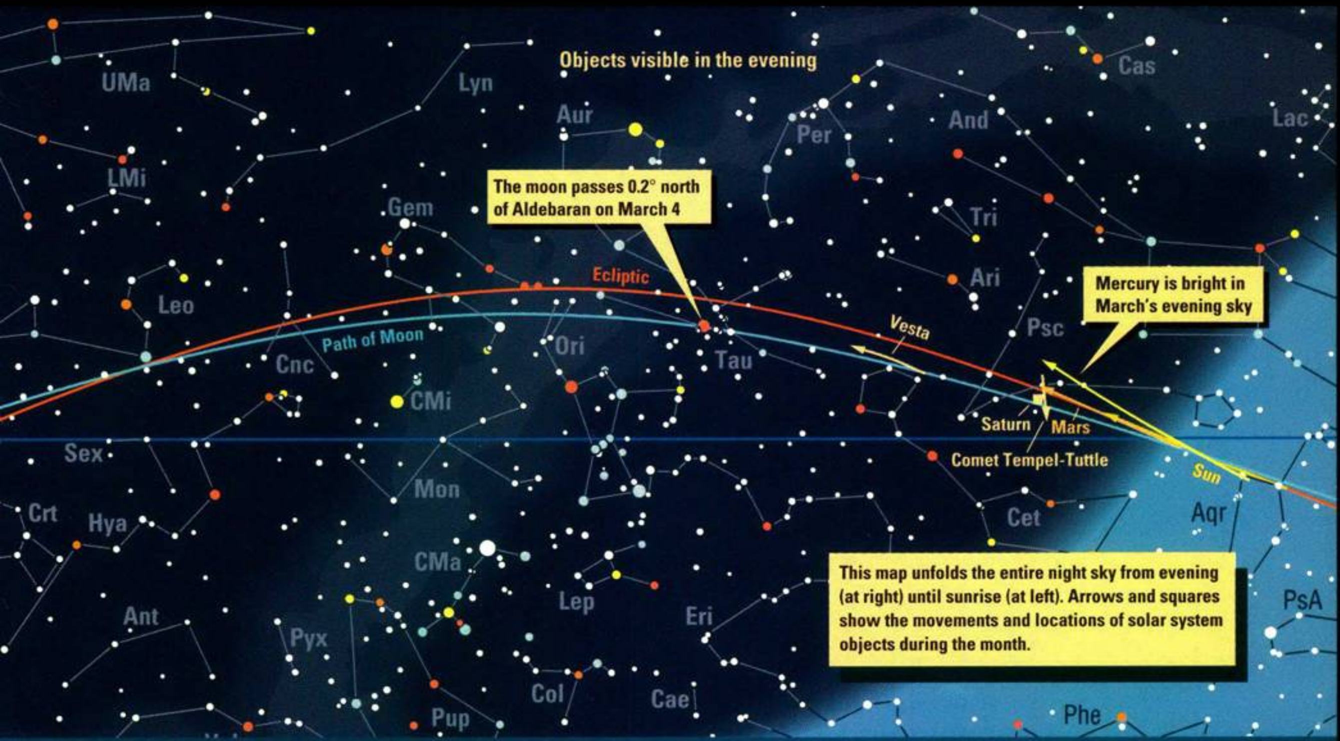




JUPITER'S MOONS



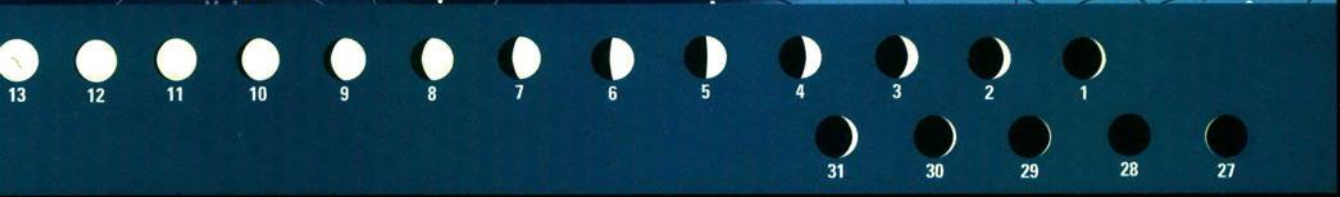
Dots display positions of Galilean satellites at 6 a.m. EST on date shown. South is at top to match the view in a telescope.


Objects visible in the evening
UMa
Lyn
Cas
Aur
And
Lac
Per
LMi
Gem
Tri
Leo
Ecliptic
Ari
Path of Moon
Vesta
Psc
Cnc
Ori
Tau
CMi
Saturn
Mars
Sex
Comet Tempel-Tuttle
Sun
Mon
Crt
Hya
Cet
Aqr
CMa
Lep
PsA
Ant
Eri
Pyx
Col
Cae
Pup
Phe

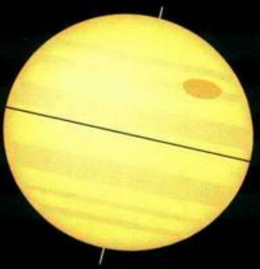
The moon passes 0.2° north of Aldebaran on March 4

Mercury is bright in March's evening sky

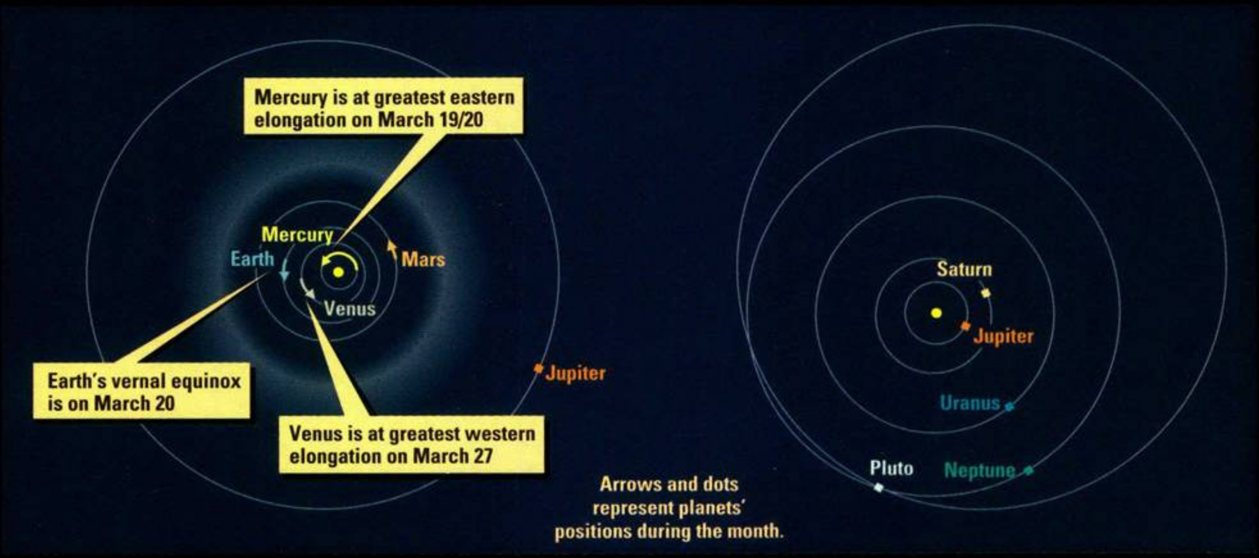
This map unfolds the entire night sky from evening (at right) until sunrise (at left). Arrows and squares show the movements and locations of solar system objects during the month.


13
12
11
10
9
8
7
6
5
4
3
2
1
31
30
29
28
27

MARS	JUPITER	SATURN	URANUS	NEPTUNE	PLUTO
larch 1	March 15	March 15	March 15	March 15	March 15
1.2	–2.0	0.6	5.9	8.0	13.8
4.0"	33.1"	16.2"	3.4"	2.2"	0.1"
99%	100%	100%	100%	100%	100%
2.318	5.957	10.234	20.568	30.735	29.762
1.401	5.003	9.347	19.853	30.143	30.047
h50.8m	22h44.8m	1h16.3m	20h55.3m	20h14.7m	16h33.2m
–1°47	–8°56'	5°37'	–18°00'	–19°29'	–9°34'



THE PLANETS IN THEIR ORBITS


Mercury
Earth
Mars
Venus
Jupiter
Saturn
Jupiter
Uranus
Pluto
Neptune

Mercury is at greatest eastern elongation on March 19/20

Earth's vernal equinox is on March 20

Venus is at greatest western elongation on March 27

Arrows and dots represent planets' positions during the month.

the same night. By March 31, the three planets are roughly in line. Saturn is now the brightest at magnitude 0.6, while Mars shines at magnitude 1.3 and Mercury at a feeble magnitude 1.7. Finding the three planets at this stage represents quite a challenge — they're only 2° above the western horizon 30 minutes after sunset.

There's a slim chance of catching an even more slender moon on March 28, when a young crescent, just 20 hours old for east-coasters, may be glimpsed. Start searching with binoculars 30 minutes after sunset. Use bright yellow Saturn to guide you to the moon's hiding place. You'll find the delicate orangy-silver arc 2° to the lower left of the planet. On the west coast, the age of the moon will be closer to 23 hours.

The bull's eye winks on the evening of March 4, as the star Aldebaran is occulted by the moon. The twosome can be found high in the west-southwestern sky at sunset. By 7:45 p.m. EST the moon's limb passes in front of Aldebaran.

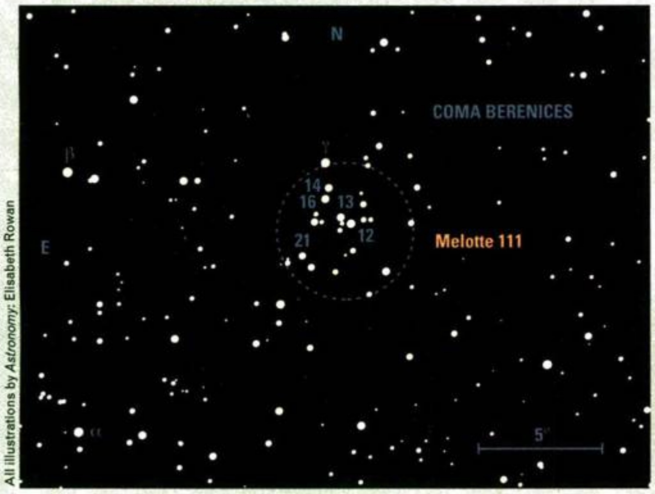
This dramatic event can be seen with the unaided eye, binoculars, or a telescope. Observers west of the eastern time zone will see the event in brighter skies. Those west of the Mississippi are out of luck. For them the entire event occurs in daylight.

The moon passes south of Castor and Pollux in Gemini the Twins on March 8. By March 12, the moon is full and undergoes a penumbral eclipse. More than 50 percent of the moon's disk will be inside Earth's brighter penumbral shadow. Careful observers may detect a slight dimming of the moon's southern limb.

Penumbral lunar eclipses are not particularly noteworthy events. They will, however, fascinate those captured by the delicate subtleties of the universe around them. The peak of the eclipse occurs around 11:30 p.m. EST.

The moon occupies the evening realm of the zodiacal light for the first half of the month, so try looking for this diffuse glow toward month's end. The zodiacal light is sunlight reflected from dust in the plane of our solar system. Its gentle radiance extends from the horizon upward along the ecliptic. During the months of March and April, the ecliptic forms a steep angle with the horizon. This improves its visibility. You also need the right conditions — very clear, dry, and totally dark skies — to observe this beautiful phenomenon.

First Views: Melotte 111, the Coma Berenices Star Cluster



All illustrations by *Astronomy*: Elisabeth Rowan

Some of the most obvious objects weren't added to the Messier or NGC catalogs. Early astronomers were so enthralled by high magnifications that they overlooked a few spectacular star clusters that were hazy blobs to the naked eye. But some of the most beautiful objects can easily be defined with a pair of binoculars. The Melotte clusters are such objects.

Chances are you've already seen Melotte 111. An acquaintance or your guide book told you it was the Coma Berenices Star Cluster. We emphasize star here because the same constellation harbors the more famous — but incredibly more difficult — Coma Berenices Galaxy Cluster.

Start your observing session at the hindquarters of Leo the Lion, and move toward the handle of the Big Dipper. The Coma Berenices Star Cluster can be found about one-third of the way along this line.

The cluster is a beautiful sight from a dark location, and binoculars provide the perfect field of view. They allow you to see this 5° clump surrounded by darkness, yet provide some fainter stardust throughout.

Other Melotte clusters of note include the Hyades and the Pleiades. For the most part, Melotte clusters have NGC designations, but the best are the few in the IC catalog, like IC 4665 in Ophiuchus and IC 4756 in Serpens Cauda.

John Chumack

Aside from Saturn, the western sky is devoid of bright stars during the early evening hours. Filling the gap below Taurus and Perseus is Aries the Ram. The constellation has three bright stars, two of them close together and pointing toward the western horizon.

Just north of Aries is a region that temporarily held a constellation called Musca Borealis the Northern Fly. Now defunct, this tiny group was introduced by Dutchman Petrus Plancius as Apes the Bee in 1613. It then was briefly known as Vespa the Wasp. Famous stellar cartographer Johannes Hevelius called it Musca on his 1687 star atlas. Eventually the constellation became obsolete, as there already existed a constellation of the same name in the southern hemisphere. But somewhere there still exists a chart by Hevelius depicting a fly pestering his neighbor the ram.

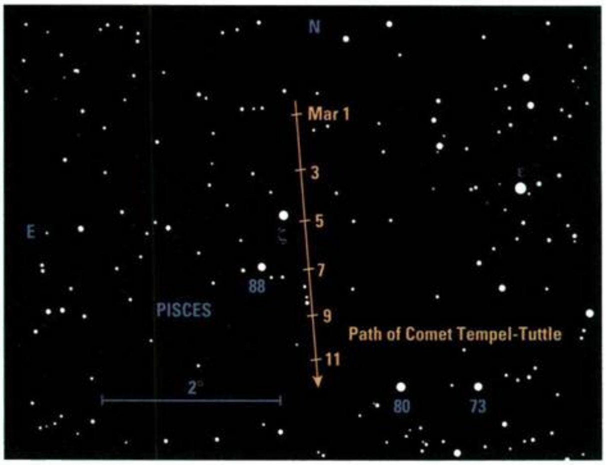
Cetus the Whale is alive and well as it descends in the west. It's followed by Taurus the Bull a couple of hours later. High in the northwestern sky Perseus stands in a protective pose over Andromeda, who is setting with Pisces. Keep an eye on Algol, the second-brightest star in Perseus. Every few days it undergoes an eclipse by a fainter companion. This causes more than a magnitude drop in brightness over a few hours.

Andromeda's mother and father, Queen Cassiopeia and King Cepheus, perform a regal descent underneath Polaris during the hours from sunset to midnight. Delightful star clusters abound in Cassiopeia and Perseus, a fine region for scanning with binoculars. In particular, look for the Double Cluster. It can be found

Goodbye Tempel-Tuttle, Hello Leonids

Did you see the Leonid meteors last November? The proximity of the parent comet Tempel-Tuttle makes a huge difference in the amount of dust that Earth sweeps up when it crosses the dirty snowball's orbit.

If you have not yet seen the comet, try to find it during the first few days of the month while the moon is still young. Make sure your sky is fairly dark, otherwise the weakly concentrated fluff ball will be nearly invisible. After March 13, the moon has left the evening sky. Unfortunately, Tempel-Tuttle is fading to below 11th magnitude. It's also being swallowed by twilight.



Will there be a meteor storm this November? Hopes are high. At the very least there should be an above average shower over the Americas, possibly exceeding the Perseids. The comet is due back in our vicinity in 33 years.

For further information on Tempel-Tuttle and the handful of comets currently in the sky, point your web browser to http://encke.jpl.nasa.gov/, or visit *Astronomy* at http://www.astronomy.com/. There, in the news section, you'll find links to the JPL site as well as other comet sites.

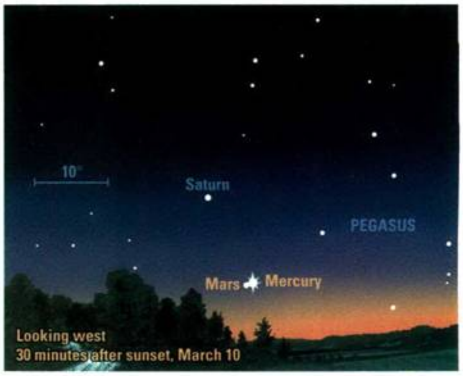
Mercury Meets Mars

First a quick reminder — watch for the moon-Mars conjunction on February 27. The twosome will be bathed in the colors of the setting sun, with the thin crescent moon just to the north of dimming Mars. By the time March 1 rolls around, the moon has climbed above Saturn while magnitude 1.2 Mars still huddles low in the twilight. It may surprise you at first, but you'll need binoculars to spot the retiring Red Planet.

To spice up the view, fleet-footed Mercury makes an appearance within a week. This generally elusive planet climbs high above our western horizon this month — a full 19° east of the sun on March 19.

Mercury shines at magnitude –1.3 on March 8 . It's so much brighter than Mars, that you'll be able to easily spot its scintillating point with the naked eye. The planet quickly skims past Mars on March 10, with Mars 1° to the left of whiter Mercury.

Check out Mars and Mercury in the eyepiece. Mercury has an 80 percent gibbous phase and spans almost 6". Mars is 2" smaller with a disk size of 4". Don't expect to see any surface detail on either rocky planet.



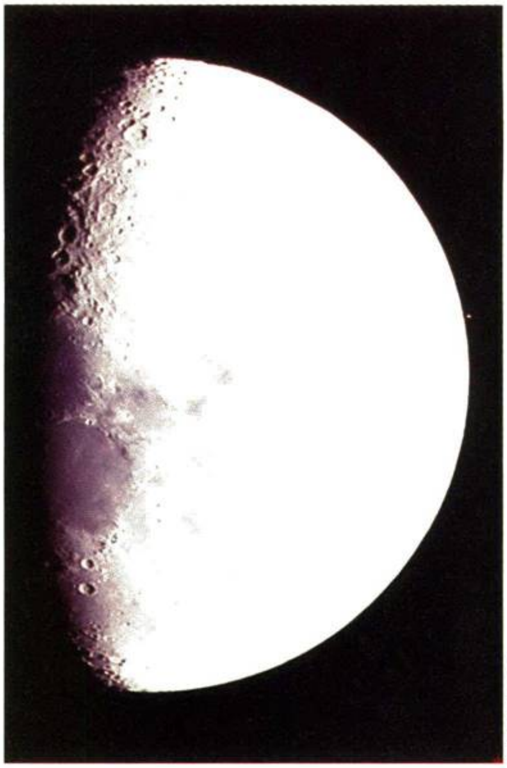
By the time March 31 rolls around, Mars, Mercury, and Saturn will be together in a nearly straight line parallel to the western horizon. Unfortunately, the threesome will also be very close to the horizon and the sun's residual glow.

The Moon Hits a Bull's Eye

The moon plays a big part in events this month. Only 12 lunar months after a delightful evening crescent moon covered up ruddy Aldebaran in Taurus the Bull, a thicker phased moon occults the bright star again. At roughly 7:45 p.m. EST on March 4, observers on the east coast will see Aldebaran wink out in a fairly dark sky.

Because the moon will be near half phase, earthshine will brighten the dark portion of the moon. This means that Aldebaran will disappear without much notice, so check the occultation time for your area carefully. Catching the star's reappearance will also be tricky. Not only will the reappearance be sudden, but it will occur on the brightly lit edge of the moon as well.

Observers west of the Dakotas will be bathed in the light of the setting sun. This will diminish the impact of the spectacle somewhat, but the sudden disappearance will still be a nice treat.

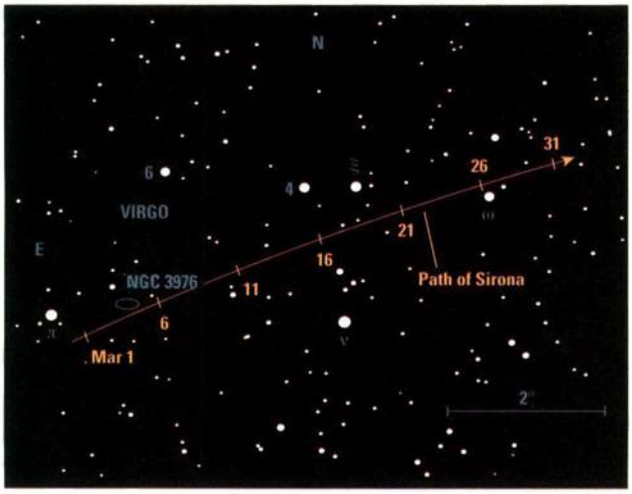

Martin Anderson

116 Sirona Pays a Visit to NGC 3976

Our mark this month? 116 Sirona, which treks through the head of Virgo the Maiden. This 80-kilometer wide rock is at opposition on March 17, when it reaches magnitude 10.8. But don't wait until the middle of the month to search for 116 Sirona, because one of the prettiest views will occur on March 5. On that night, the edge-on galaxy NGC 3976 will appear to have a supernova near its central regions. That's Sirona masquerading as a guest star. Make sure you're in a dark location, and start searching after the moon has set. NGC 3976 has a total brightness of about magnitude 11.5, but once you spread that glow out across its 4' by 1' extent, it seems fainter.

On March 19, the asteroid slides about 30' south of the bright star Xi (ξ) Virginis and by March 26 it's a mere 12' north of Omega (ω) Virginis.

116 Sirona was discovered by C. H. Peters in 1871.



midway between the two constellations. Sometimes referred to as the "Sword Cluster," the Double Cluster represents the sword held by Perseus. Known as far back as 150 B.C., the stars of this cluster are brilliant supergiants — if the sun were placed at its distance (more than 7,000 light-years away) it would be a feeble 16th-magnitude star.

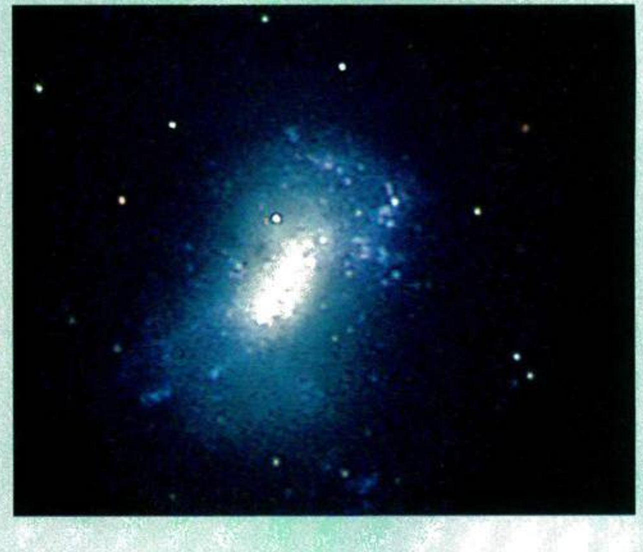
High above Perseus is the brilliant yellow star, Capella, in Auriga the Charioteer. This prominent northern constellation is associated with several mythological stories. The most popular is that of the king of Athens, Erichthonius, a great horseman and charioteer.

Auriga holds three bright open clusters; M36, M37, and M38. They are dimmer and more distant than the Double Cluster, but they offer spectacular views in a telescope. The Pleiades (M45), or Seven Sisters, are a bright distraction nearby.

High in the southwest the stars of winter dominate the stellar canopy. More than half a dozen stars brighter than 1st magnitude inhabit this region. Two more open clusters are targets for binoculars: M35 at the foot of the twin Castor in Gemini, and M44 in Cancer the Crab. Cancer is a hard constellation to find, but a pair of dim stars roughly midway between Pollux and Regulus mark the approximate location of M44, better known as the Beehive Cluster.

Wriggling beneath Cancer is Hydra the Snake. Alphard, meaning the "Solitary One," shines alone with only a few faint stars to keep it company. One of them is the triple star 29 Hydrae. It rests 0.5° south of Alphard and is worth a brief stop.

OBSERVER'S CHALLENGE: H II regions in NGC 4449


Jack Newton

There's little in the universe of nebulae that compares to the likes of the Orion Nebula, Eta (η) Carinae, and the Lagoon Nebula. They fire the imagination. What would it be like to get really close to one?

You can even see these glowing gas clouds in other galaxies. One such region is NGC 604 in M33, the Pinwheel Galaxy. It's so bright that it was given its own catalog number, and a Hubble image of it was featured on the cover of *Astronomy*'s December 1996 issue.

NGC 4449 can be found high in Canes Venatici, some 3° north of Beta (β) Canum Venaticorum. It is an irregular galaxy, sporting more than 20 bright ionized gas clouds. In photographs NGC 4449 looks almost tortured. It's actually in a state of high star production.

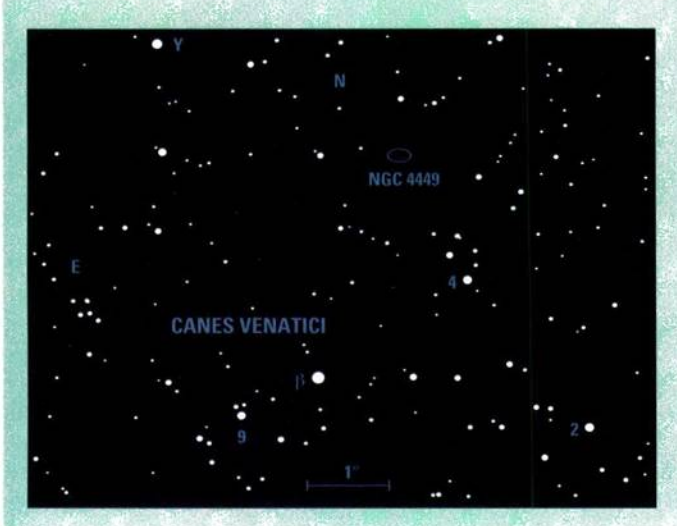
This galaxy's relatively bright magnitude of 9.5 allows you to view it with reasonably high magnification. If your telescope has a drive and the night sky is willing, crank the power to 300x. For the highest contrast, place a dark shroud over your head and eyepiece to block out all extraneous light.

An 8-inch scope reveals a distinct mottling and one or two ill-defined knots. Larger instruments show progressively more knots.

Here's a surprise: Use a nebula filter to isolate the H II regions. Of course the field of view will go really dark since filters block much of the galaxy's natural starlight, but the H II regions come through enhanced — just like the Lagoon Nebula does with a filter. In a 16-inch scope I was once treated to an astounding sight. There were so many pinpoints and tiny blobs that this galaxy looked like a really faint but resolved star cluster.

Many other galaxies offer H II regions. Try flipping through an album of pictures to find the interesting ones, then apply some power.

NGC 4449 is located at 12h28.2m 44°05' (2000.0).



As the evening progresses and midnight approaches, Leo regally keeps watch high in the south. The other stars of spring, including Virgo the Maiden and Bootes the Herdsman, gather in the east. As these spring stars rise and the winter stars set, they take with them the Milky Way.

The winter Milky Way is considerably fainter than its summer counterpart. When we view the winter portion of our galaxy, we gaze out into intergalactic space through an outer arm of the Milky Way. Our line of sight is away from the galaxy's center. During the early morning hours, the other side of our galaxy begins to rise with the stars of summer. This section of the Milky Way is much brighter. Here we look toward the galaxy's center along its star-rich plane.

Closer to home, the second planet from the sun, **Venus**, rises in the early morning. It recently passed between us and the sun and now shines stunningly bright as the "Morning Star." As it speeds ahead of us in its smaller, faster orbit, more and more of its illuminated hemisphere becomes visible. This, however, has little effect on the planet's brightness because its path is also taking it farther and farther away from Earth. Venus reaches its maximum elongation (47°) west of the sun on March 27.

In early February, Venus had a large 55" disk and a thin crescent phase. On March 1 this is replaced by a chunkier crescent with the disk about 35" across. By the end of the month the disk shrinks to 24" and Venus appears half illuminated, a phenomenon called dichotomy. The shrinking apparent size combined with the growing illumination has a steadying effect on the planet's magnitude. Though the planet undergoes great changes in its appearance and distance, the planet's magnitude only dims from –4.6 to –4.4.

While you've got your binoculars out to spot the changing phase of Venus, try pointing them to **Uranus** and **Neptune** as well. These two outer planets are both visible in binoculars, but you must know exactly where to look. Venus is a handy tool for that task.

On March 7, Venus is 3.8° north of Neptune. An additional guide to finding 8th-magnitude Neptune is 6th-magnitude Sigma (σ) Capricorni, which is located nearby. On March 19, Venus passes 3.3° north of Uranus. Uranus will be one of two 6th-magnitude objects in that area. The other is the star 19 Capricorni.

Jupiter adds its bright presence to the morning skies in late March. Reappearing from the sun's glow after last month's conjunction, it shines at magnitude –2.0. Though the planet never reaches the brilliance of Venus, the twosome still provides a stunning show. Each morning, Jupiter will appear higher in the sky. It's preparing for a close conjunction with Venus late next month.

A waning crescent moon glides by Venus and Jupiter between March 24 and March 26. It occults Jupiter for the Atlantic coast of North America on the 26th. The event occurs low in the sky and shortly before sunrise. Though it will be hard to observe — nearly in daylight — it's still worth a try.

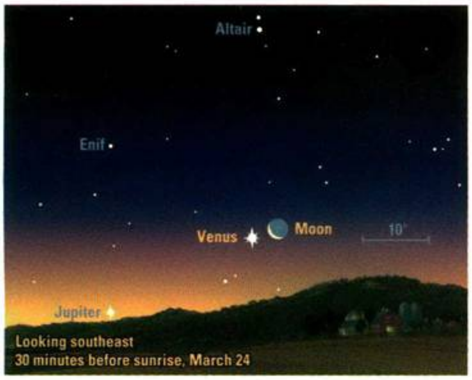
The sun lies on the ecliptic and celestial equator simultaneously at 2:55 p.m. EST on March 20, marking the vernal equinox. This is the first day of spring in the Northern Hemisphere, and the first day of autumn for those in the Southern Hemisphere. ■

Martin Ratcliffe is Director of Theaters at the Exploration Place in Wichita, Kansas. Alister Ling is a meteorologist working for Environment Canada in Alberta.

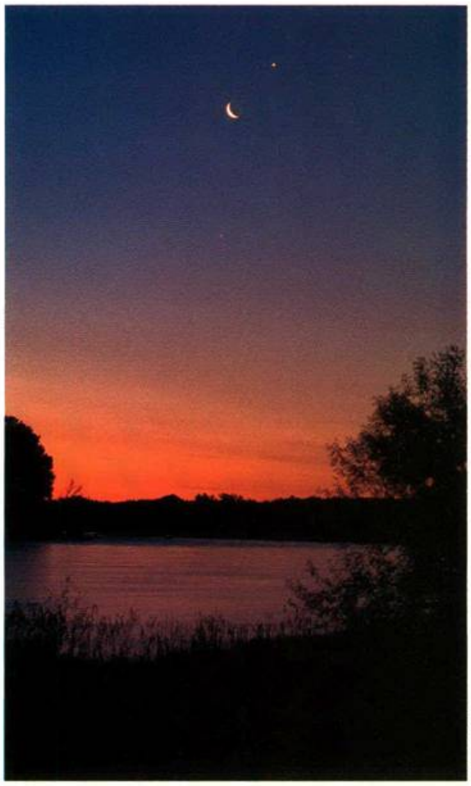
Waning Moon, Waxing Venus

The old, waning moon hangs a few degrees westward of blazing Venus on the morning of March 24. The next morning offers a beautiful photo opportunity. The thin crescent moon will be closer to the horizon with its horns pointing toward Venus.

Meanwhile, Venus continues its shrinking act, starting the month in a crescent phase with a 36"-diameter disk. Through the month its silhouette changes, growing to a half-phase shape some 24" across by month's end.



Looking southeast
30 minutes before sunrise, March 24



John McNal

Moon Occults Jupiter for East-Coasters

This occultation offers those living in northeastern New England and the Canadian Maritimes a challenge. The event begins at 4:55 a.m. EST on March 26, when Jupiter takes slightly more than a minute to disappear behind the moon. The challenge stems from the fact that the event takes place a few degrees above the horizon, in the typically murky lower atmosphere. Equally as tough will be detecting Jupiter as it emerges from behind the moon at around 5:50 a.m. EST. By that time, the first set of observers are experiencing sunrise. That means the sky will be brighter and the dark limb of the moon nearly invisible. Check the reappearance time and position for your area carefully by using a computerized observing program. Your local planetarium or university should also be able to help.

Will contrast be better for those closer to longitudes near Lake Erie? The sun won't be up, but the low altitude of emerging Jupiter will add to the challenge. Spotting the reappearance of Jupiter's moons is also tough. The bright glare of the sky all but make these dots invisible. If your scope is larger than 8 inches, give it a try.

J. Guertin & R. Baldridge

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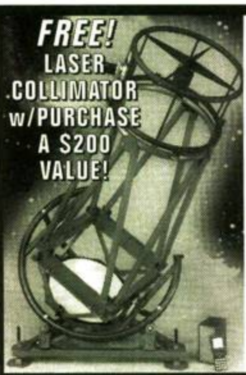

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SEEING INTO

A telescopic trek reveals the glory of an energetic universe.

by Alan Goldstein

EARTH ORBITS IN A peaceful corner of a noisy universe. We certainly have more than enough nuclear weaponry to wipe ourselves off the planet, but all of the energy from all of the atomic explosions that could occur on Earth would barely be detectable on the radio receiver of an astronomer in a nearby solar system. Around us lurk the real powerhouses of the universe — energetic stars, the expanding shells of supernovae, erratic galaxies, and distant, luminous quasars. Indeed, we sit cloistered in a violent universe.

Fortunately, all of the energetic (and most dangerous) members of the universe lie at tremendous distances. We can see some members with the unaided eye, their naked energy masked by hundreds of light years. Others are dimmed by interstellar dust or the immense gulf of space stretching hundreds of millions or even billions of light-years away. To see them, we need a telescope and the secure, calm comfort of a clear, starry night.

Our first targets are two 1st-magnitude stars, Rigel and Deneb. Each represents a rare breed of star known as a blue supergiant. The Milky Way's population of such stellar powerhouses is scant, making up no more than several thousand stars out of a hundred billion. Blue supergiants are characterized by masses greater than 10 times that of the sun. Their surface temperatures may exceed 10,000 Kelvins. They are thousands of times more luminous than the sun. As blue supergiants age, they fuse heavier and heavier elements until finally creating an iron core. Ultimately the star explodes as a supernova. Such explosions may be so bright and energetic that they briefly outshine the entire galaxy in which they

Orion's Brilliant Rigel (with Reflection Nebula IC 2118)

BILL AND SALLY FLETCHER

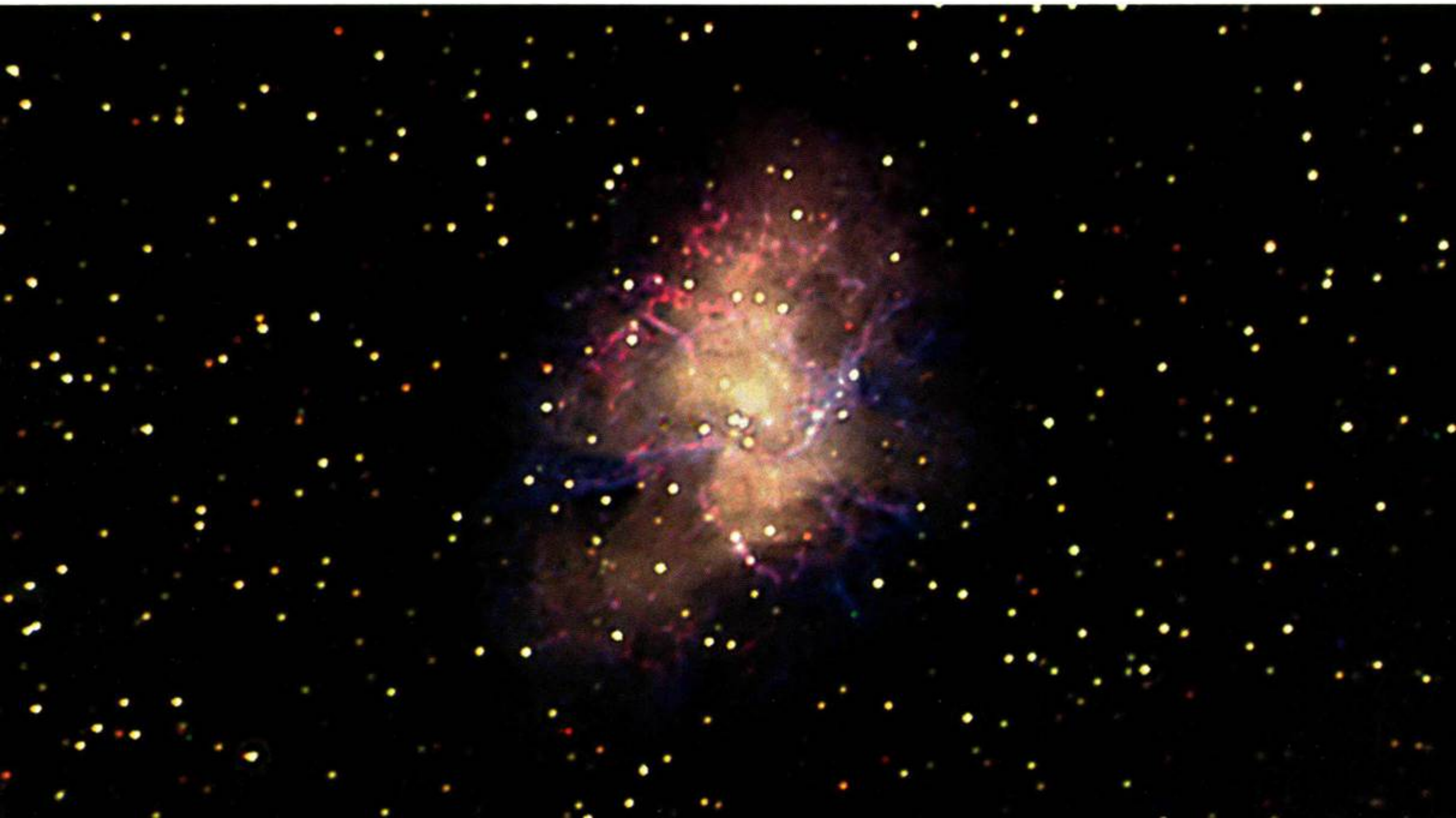
(8-inch f/1.5 Schmidt camera, Tech Pan film, tricolor composite of 16-minute red, 58-minute green, and 68-minute blue exposures)

VIOLENT CORNERS

lie and may be visible in small telescopes in galaxies lying a hundred million light-years away. The life of a blue supergiant star is short compared to other stars, comprising only a few million years. Consequently, while they continue to form by collapsing clouds of dust and gas, they rarely leave the areas of their birth before exploding in nature's most violent events.

The brightest star in Orion, **Rigel** (Beta [β] Orionis), is a blue supergiant with a spectral type of B8. It is also the seventh brightest star in the sky. This powerhouse lies some 850 light-years away yet shines in our sky at magnitude 0.1. Rigel is 50,000 times more luminous than the sun and 25 times more massive. Were it placed only 32.6 light-years away, the standard distance used by astronomers to compare star brightnesses, Rigel would shine brilliantly at magnitude –8.4 — some 40 times brighter than Venus. Telescopic views (especially if somewhat unfocused) show Rigel with a bluish hue. Rigel is a binary star; a magnitude 6.8 companion lies 9.5" from the primary. The most brilliant luminary in Cygnus, Deneb (Alpha [α] Cygni), is another energetic supergiant star; its spectral type is A2. At magnitude 1.3, it's the 18th brightest star in the sky. However, Deneb is 1,500 light-years away and shines through a thick blanket of interstellar dust. About 7° southwest of Deneb, just southwest of Gamma (γ) Cygni, lies **P Cygni**, a peculiar star of spectral type B2. It is one of the most energetic stars known. Despite an estimated distance of 5,900 light-years, P Cygni shines at magnitude 4.8, making it visible to the naked eye under a reasonably dark sky. At the standard brightness distance of 32.6 light-years, P Cygni would shine at an impressive magnitude –9.0, almost as bright as a first quarter moon. All the while, P Cygni continues burning furiously; it loses one sun's worth of material every 2,500 years.

Many massive stars have already expended their cache of fuel and gone into the stellar graveyard. Such was the



The Crab Nebula

JACK NEWTON

(25-inch f/5 reflector, Pictor 1616XT CCD camera, tricolor composite of 5-minute red, 12-minute green, and 20-minute blue exposures)

Supermassive Elliptical Galaxy M87

JERRY LODRIGUSS

(5.1-inch refractor at f/6, hyper-sensitized Fuji Super G 800 film, 45-minute exposure)

case of the star that created the **Crab Nebula** (M1, NGC 1952) in Taurus. In A.D. 1054 observers recorded a bright supernova in this part of the sky. The Crab Nebula is what remains of the star that blew itself apart, observed now some 943 years later. The nebula's odd name was coined by William Parsons, third earl of Rosse, who observed filaments within the nebula and likened them to the legs of a crab. He began using the name Crab Nebula in 1848.

As are other supernova remnants, the Crab is a strong source of gamma rays and x rays. The energy from the explosion is slowly diminishing in intensity, however. Much of the strongest radiation comes from a rapidly spinning pulsar embedded in the center of the Crab's gas cloud. The pulsar is a tiny neutron star a mere six miles across. It is incredibly dense, squeezing at least 1.4 solar masses into this tiny sphere. The star rotates on its magnetic axis an astounding 33 revolutions per second. At 16th magnitude, the pulsar is a challenging sight even in the largest amateur telescopes. The Crab itself glows at magnitude 8.4 and can be seen through binoculars. It lies 1° northwest of Beta Tauri. In small telescopes the Crab appears as an oval glow 6' by 5' across. Eight-inch or larger scopes show slight indentations to the oval giving the nebula the general shape of an "S."

An even stranger dying star resides in **SS 433**, a faint, enigmatic object in Aquila. It varies erratically between magnitudes 13.5 and 16. Under dark, moonless skies the star might be visible in a 10-inch telescope, but you may need a 14-inch scope if SS 433 has faded.

Among SS 433's curious characteristics is the fact that its spectral lines shift dramatically on a daily basis. This indicates an energetic outflow of material in the range of thousands of miles per second. SS 433 can fade more than 40 percent in brightness without warning. The system may consist of a "normal" star and a neutron star with an accretion disk emitting more than half of the star's light. The star is an intense x-ray emitter, producing gamma rays and radio emission as well. The system is so energetic that it noticeably distorts a gas cloud as far as 150 light-years away.

High energy emission and explosions aren't limited to stars, however. Galaxies are in on the act too. The driving force behind these peculiar galaxies is thought to be massive black holes surrounded by accretion disks. These galaxies range from weak radio galaxies to quasars, the most powerful objects in the universe, with Seyfert galaxies and BL Lacertae objects in between. Seyfert galaxies provide a good starting point for observing high-energy galaxies. These objects are named for the American astronomer Carl Seyfert, who studied them in the early 1940s. Seyfert galaxies have energetic centers that contain fast-moving gas clouds and bright, star-like cores. These cores vary in brightness during a period as short as a few days.

Nestled in Cetus, **M77** (NGC 1068) is a magnitude 8.9 type Sb spiral. It is characterized by a bright stellar core with a faint outer spiral structure. M77 spans 6.7' by 1.5' and is the brightest Seyfert galaxy in the sky.

Seyfert Galaxy M77

JACK NEWTON

(25-inch f/5 reflector, ST-6 CCD camera, tricolor composite of 5-minute red, 12-minute green, and 20-minute blue exposures)

Peculiar Galaxy NGC 5128
JAMES R. FOSTER

Small telescopes reveal an oval patch with a sharp, stellar nucleus. Ten-inch or larger scopes reveal a fainter, outer spiral structure. Another bright Seyfert galaxy, **NGC 4151**, can be found in Canes Venatici. Visually, it appears as an orb glowing at magnitude 11.2, spanning 2.5' by 1.6', with a bright nuclear region. There is no distinct bar visible in photographs.

Other high-energy galaxies populate the sky. **NGC 5128** in Centaurus, known to radio astronomers as Centaurus A, is a powerful emitter in long radio wavelengths, more than 1,000 times stronger than the Milky Way. Like other explosive galaxies, the driving "engine" inside NGC 5128's core is thought to be a supermassive black hole. In visible light, NGC 5128 resembles an elliptical galaxy bisected by a dusty belt. At magnitude 7.2, this is one of the brightest explosive galaxies in the sky. At –43° declination, however, it is far enough south for many Northern Hemisphere observers to be difficult to observe. From the southern United States the galaxy is visible in binoculars. The galaxy's dusty girdle is visible in telescopes as small as 60mm in aperture. Larger scopes increase the contrast between the dust and starlight within the galaxy's dusty center.

King of the elliptical galaxies, Virgo's **M87** (NGC 4486) is one of the strongest radio sources in the sky. Known to radio astronomers as Virgo A, this galaxy is among the largest members of the Virgo cluster of galaxies, and it contains the equivalent mass of nearly a trillion suns.

This supergiant elliptical contains a small jet in the nucleus, first noted by American astronomer Heber Curtis in 1918. In 1948 astronomers found M87 to be the fifth most powerful radio source in the heavens. In the 1960s, with the advent of x-ray detectors, M87 was found to be a prodigious source of x rays. The jet emanating from the nucleus stretches 4,000 light-years and is moving at relativistic speeds. M87 shines at magnitude 9.2 and in backyard scopes appears 3' across. Under good skies, it can be viewed in ordinary binoculars. Small scopes show a glowing orb. Eight-inch or larger instruments show the bright nucleus well.

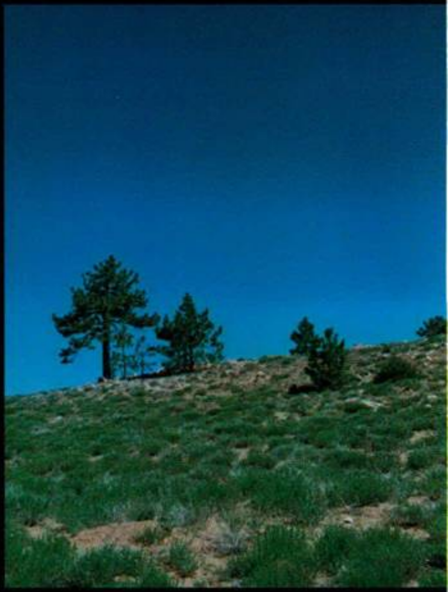
The most powerful of the universe's zoo of celestial objects are quasars. Thought to be the highly energetic centers of infant galaxies, powered by supermassive black holes, these objects are just a fraction of a light-year across. Yet they shine brightly across billions of light-years of intergalactic space. Most vary in brightness by the hour. In 1963, Caltech astronomer Maarten Schmidt analyzed the spectra of mysterious radio sources 3C 273 and 3C 48 and found their odd spectral lines to be caused by ordinary elements redshifted an extraordinary amount.

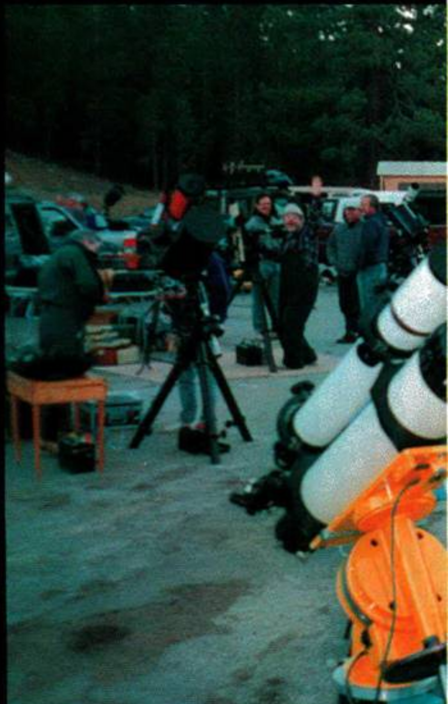
3C 273 in Virgo is the brightest quasar in the sky. Glowing at magnitude 12.7, this quasar lies about three billion light-years away. The light we see from 3C 273 departed the quasar when blue-green algae and cyanobacteria were the most advanced life forms on Earth. Quasars appear starlike; the key to recognizing 3C 273 among the foreground stars is to use the accompanying photo.

These celestial beasts are visible on any clear night. They are deceptively beautiful and calm as we stare at their soft light in the eyepiece. Only science can show that they are awesome emitters of furious radiation and make us thankful that indeed we live in a calm, ordinary part of the cosmos. ■

Alan Goldstein, co-founder of the National Deep Sky Observers Society, has written many articles for Astronomy.

The Call o





f Mt. Pinos

In the Southern California hotbed of astro-imaging, one site has become king of the hill.

Story and photos by Tony Hallas

IT IS THE 4TH OF JULY WEEKEND, 1997. MY WIFE DAPHNE and I are on our way up to Mount Pinos via the backroads from our house in Oakview, California. Reports of freeway closures and delays stream in. It's hot. The truck fan whirrs in and out as the truck struggles to pull the trailer up to an 8,000-foot elevation. Back on the freeways astronomers are marooned in stop-and-go traffic, but as they claw their way to the top of the mountain they are rewarded with 75° F, crystal-clear air perfumed with the smell of the magnificent pine trees for which the mountain is named.

Mount Pinos is situated about midway between Los Angeles and Bakersfield. Rising 8,831 feet from the Cuyama Valley floor, the peak has long had special meaning to humans. It stands smack dab in Los Padres National Forest on the border between Ventura and Kern counties, about 10 miles west of Frazier Park. Ancient Native Americans were familiar with its veritable bounty of scenic and spiritual beauty and plentiful natural resources.

Today the mountain is still sacred to the Chumash Indians. It's also sacred to Southern California's amateur astronomers. Dark of the moon summertime weekends can bring more than 100 telescopes of all sizes to the parking lot near the summit. The mood is relaxed and amiable despite the crowds. Astro-imagers set up at the north end of the lot and stand guard over their precious exposures. The rest of the lot is occupied by observers with telescopes from 3 inches to 30 inches visually probing the depths of the universe. As the temperatures cool and the skies darken, an occasional motorist, headlights blazing, stumbles on this mass of now

Clockwise from far left:

Bill and Sally Fletcher specialize in high-resolution color shots of clusters, nebulae, and galaxies; they sell prints and bookmarks.

Pinos's scrub vegetation growth and stands of pine nestle underneath a typically stark blue sky. It's an inviting landscape for astronomy.

Bob and Janice Fera are leading the next generation of color imagers who shoot from Pinos; they specialize in deep-sky photography.

The large parking lot atop Pinos can be jammed with a large array of high-tech equipment, particularly on summertime nights.

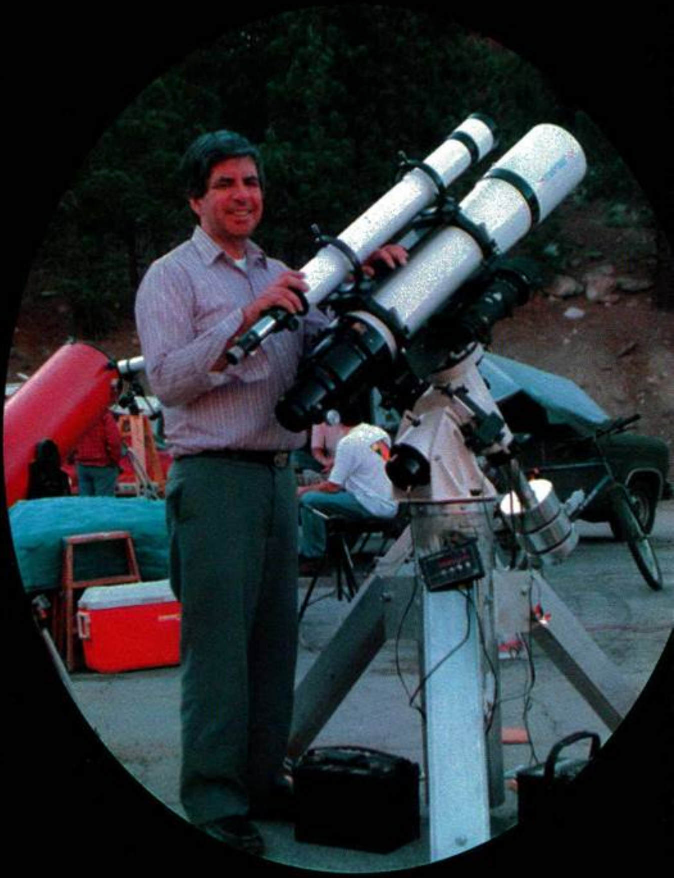
maniacal people. Shouts of "Lights! Turn off your lights!" echo across the pavement. Aside from that occasional interruption, all is relatively quiet, the dedicated skywatchers and skyshooters eking the most from their precious moments under a darkening sky.

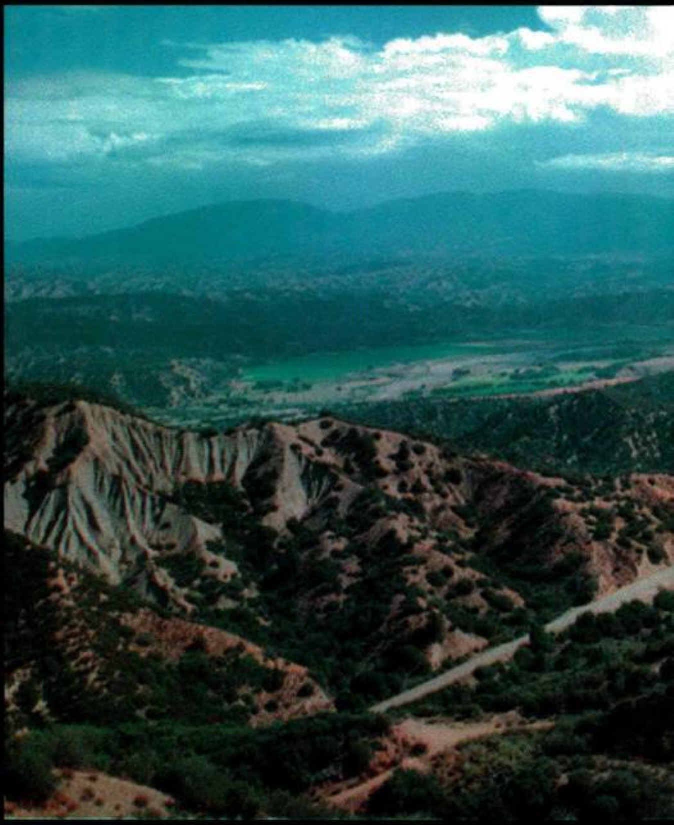
Pinos is famous for its runs of clear nights. The peak is south of the winter storm track of Oregon and Washington and west of the monsoons that strike Arizona and New Mexico. Because of this, amateur astronomers have been coming to the mountain for a long time. Dick Nelson, founder of the telescope company The Optical Craftsmen, was one of the pioneers of Pinos. He believes the site's grand, dark skies were discovered by deer hunters roaming the region. In the 1950s, a large star party at Pinos "consisted of 15 or 20 people," says Nelson. He thinks there was no observable light pollution at all back then, and the trees were much shorter, meaning that observers today have lost 5° or so of horizon by comparison.

"In the early days at Pinos, we used to argue about whether or not the Veil Nebula or the North America Nebula was visible in a backyard telescope," Nelson says. "Those were the days. But in the 1960s, technology began to push ahead and Pinos evolved as well."

During that tumultuous decade, astronomers gathered on Pinos in small numbers but with increasingly sophisticated equipment. Tom Johnson, the man who started Celestron, brought an 18-inch scope built with a strut design. With the advent of the Schmidt-Cassegrain telescope the numbers of amateurs coming to Pinos increased rapidly, making the two-hour drive from Los Angeles easier to contend with because setting up the scope was so easy. One amateur who fell into the SCT tradition is Marty Germano, a postal worker who lives in Thousand Oaks. In 1972 Germano bought an 8-inch SCT and began to photograph deep-sky objects from the summit of Pinos. He is now elder of the mountain — the Pinos astro-imager of longest duration.

Germano specializes in black-and-white photography of galaxies, clusters, and nebulae, and hundreds of his images have appeared in *Astronomy*, *Deep Sky*, and other publications. Germano's trailblazing experience has helped to guide the whole direction of astrophotography — from Schmidt cameras to 103a-F film to hypersensitized Tech Pan, and he has aggressively gone after little-known objects more than anyone else. (He has not yet taken up CCD imaging, however.) "Pinos is still a pretty good spot," says Germano. "It can be really dark when clouds and fog cover the light pollution from Los Angeles and Bakersfield, the seeing is usually good to excellent, and there's good wind protection from trees." What more could an astro-imager ask for?





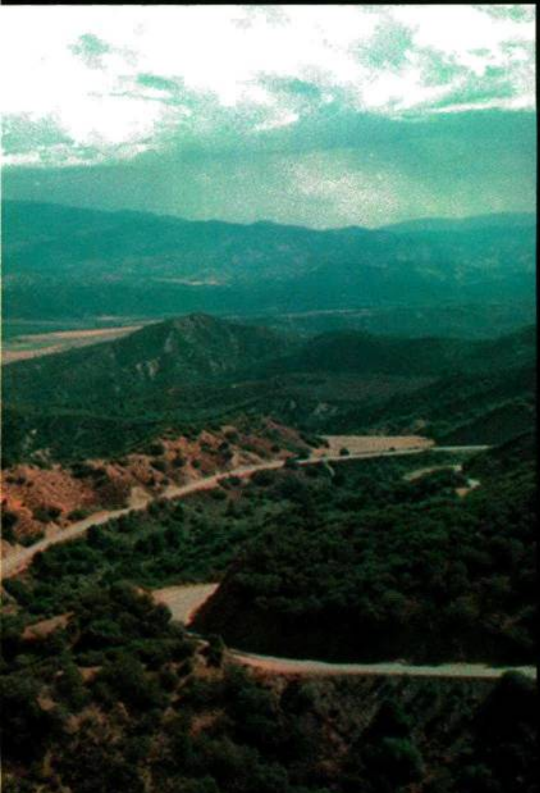
Clockwise from top left:

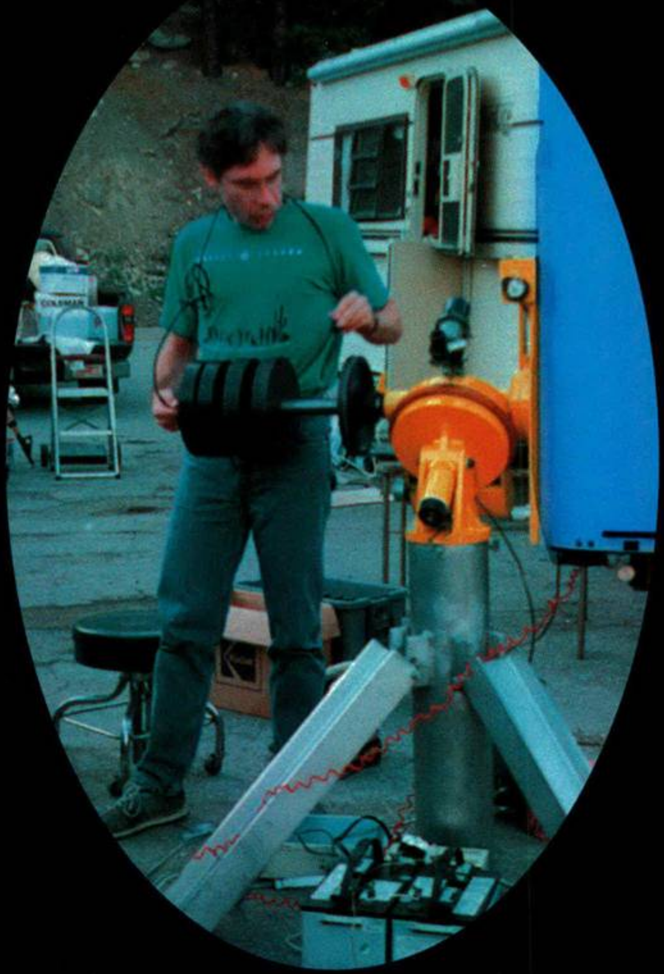
Michael Stecker has followed Germano's lead by shooting deep-sky objects off the beaten path, although he does it in color.

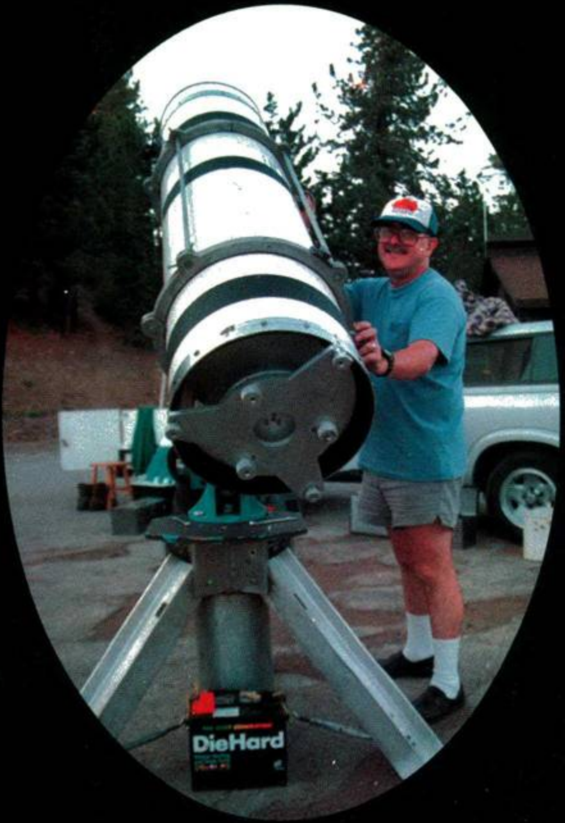
The mountain's lush fields filled with flowers and pines combine to produce a soothing fragrance and relaxed atmosphere.

Even during the summer, nighttime cold can freeze the enthusiasm of diehard skyshooters if they are not properly bundled in advance.

Monsoon clouds rise above Mt. Pinos (background), creating a dramatic scene with foothills, scrub pine, and mountain roads.



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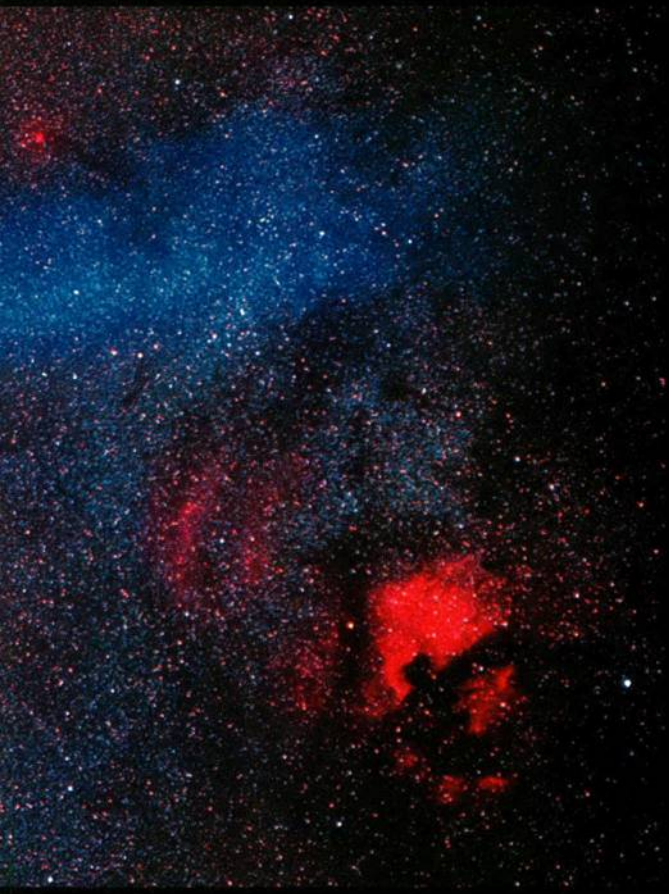

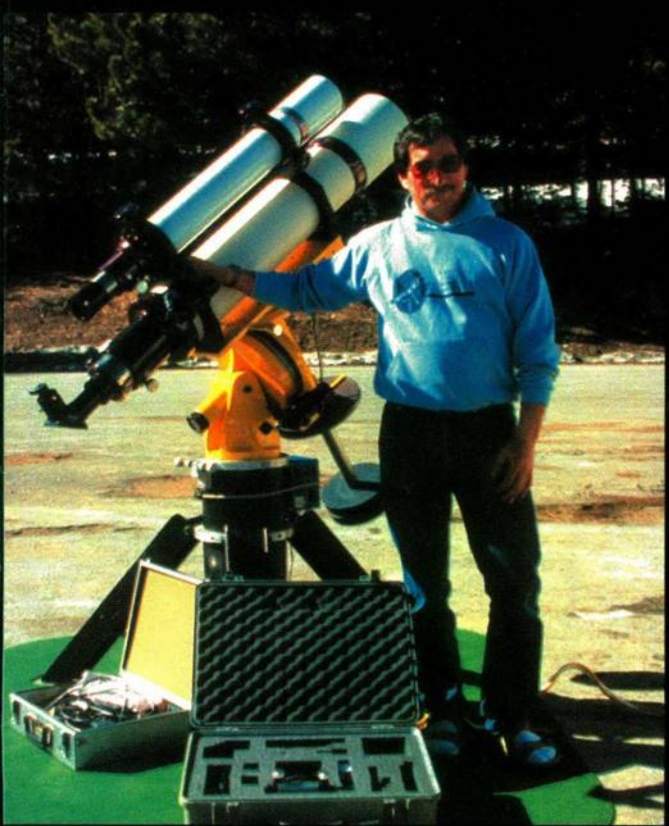

There are times when life on Pinos could be easier. Daphne and I have awakened to snow falling on our telescopes, unpredicted hail storms, 50-mph winds, thunderous lightning storms, and torrential downpours. In contrast to the mellow nights in the summertime, the winter months find only the dedicated and insane braving the intense cold. This special group, mostly made up of astro-imagers, has come to be called the Mount Pinos Rat Pack (so named for their tenacity and the way everyone looks after two nights of fighting the elements). The members include Germano, Kim Zussman, Mike Stecker, James Foster, Bill and Sally Fletcher, Bob and Janice Fera, and Daphne and me. During some of the months, the snow gets so deep that roads on top of the mountain are closed. When that happens, we go to the desert or head for lower peaks like Pine Mountain Pass.

But most of the time, the Pinos gang hangs together on Pinos. The growing numbers also bring politics. Plans exist to expand the Pinos parking area to accommodate the hordes of cross-country skiers in the winter. There is now a $30 yearly fee to use the lot and the surrounding forests. Facilities are provided by Nature.

But it is a summer night in July now, and all is peaceful. As the stars wheel above, shadows become bears, noises become coyotes, and I find myself staring up into the universe wondering about it all. The autoguider faces the alien world alone. An hour later the star party starts in earnest. In the dim light forms move about, but another world presides as the Milky Way stretches across the sky. "Oohs" and "aahs" drift from the crowd as a 20-inch telescope captures the Whirlpool Galaxy or M13 or a hundred other wonders. The parking lot that by day was the domain of mountain bikes and hikers and bird watchers has become home to the astronomers.

As the night grows old, I feel like I'm half dead after a long week. But the next morning, following a good night's rest, I am revived. The cool morning air on Pinos is fragrant with the smell of pine and wildflowers. From a lookout point to the north, I can see the snow patches on the Sierras many miles away. Below me a brown layer of pollution seems to be choking Bakersfield, but above me, a deep blue sky speaks of more clear nights to come. ▣

Tony Hallas is an astrophotographer whose work has graced Astronomy's *pages for many years in a great many stories.*

Clockwise from far left:

Kim Zussman's work, like that of Germano's, has largely focused on creating stunning black-and-white imagery.

Comet Hale-Bopp passing close to the North America Nebula provided Mt. Pinos's astro-imagers with a stunning target in 1997.

The author displays the astrophoto rig with which he has created some of the most memorable color photos of the heavens ever made.

Marty Germano is the ranking Pinos photographer, having shot mostly black-and-white deep-sky shots since the mid-1970s.

The approach of dusk on Pinos brings with it a crowd of vehicles and a hectic scramble to set up and polar align telescopes.

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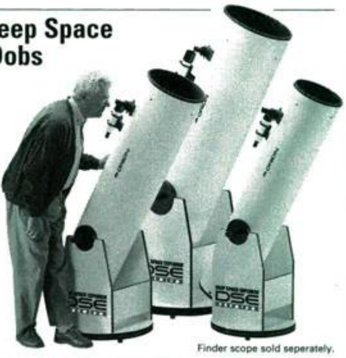

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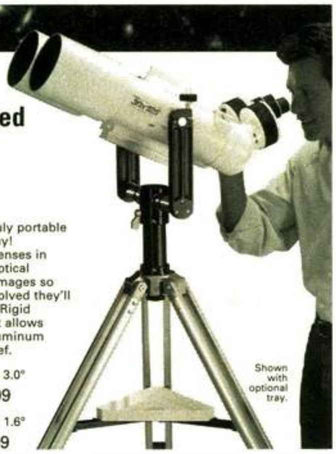

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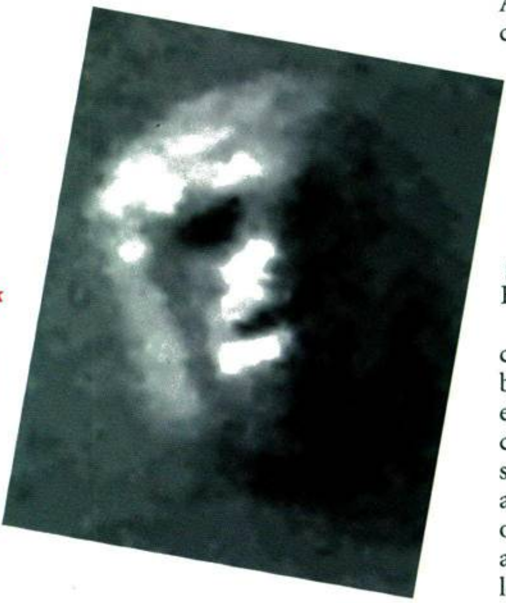
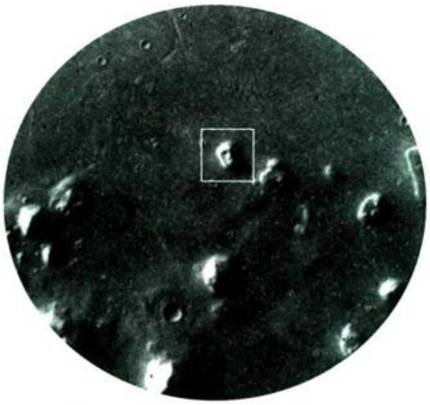
Face on Mars, Faster-Than-Light, Europa's Ocean

Q: Does NASA have any plans to send a probe to the so-called "face on Mars" and the pyramids on Mars, which some people believe might be an artifact of an extraterrestrial civilization? — *Richard Galati, Jr., Staten Island, New York*

A: No, there's no special plan to send a probe to the "face" and pyramid region Cydonia. The overwhelming majority of planetary scientists do not believe there is any compelling evidence than anything strange exists in that region. Certainly planetary scientists, including myself, are looking forward to getting images of that region from the Mars Global Surveyor mission (see "Red Planet Rendezvous," page 50). Such images are included in the spacecraft's targeting plans.



The Face on Mars: Natural formation or ET artifact? NASA/JPL



The purported face and pyramidal hills, in my opinion, are not significantly different than other natural formations we have seen on Mars, Earth, the moon, and other planets. When looking at shaded craggy hills, you can often see face-like or other patterns under certain lighting conditions. After all, there is a great stone face in New Hampshire — The Old Man of the Mountain — and others elsewhere on Earth. There are also a lot of odd formations on the moon, such as one that's jocularly known as "the baby" and another known as "the skull." But nobody gets excited about those because most people realize that we tend to see shapes that look familiar in natural formations, particularly ones that resemble a human face.

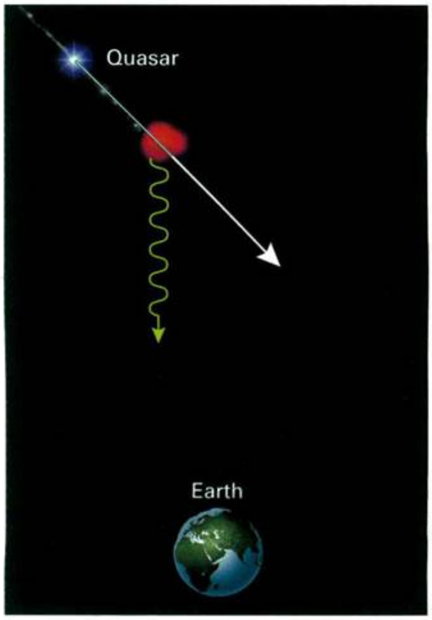
I hope Mars Global Surveyor does obtain high resolution pictures of the region under new lighting. But even if we see natural hillsides, as I expect, I am not sure that will end the fuss, since certain media thrive on claims of extraterrestrial visitations. Some will probably claim that NASA doctored the images. In my recently published novel *Mars Underground*, I jokingly predicted that after Mars Global Surveyor photos show a normal hillside, the Face on Mars enthusiasts will say that it proves there is intelligent life on Mars because the martians obviously changed the hillside to look natural after the Viking mission! — *William K. Hartmann, Planetary Science Institute*

Q: Jets from some quasars seem to violate relativity by traveling faster than the speed of light. Is there a simple picture description to explain this? — *Mike Barnett, Far Rockaway, New York*

A: Good question. You are indeed correct that blobs of material in some quasar jets appear to be traveling faster than the speed of light, which would be a direct violation of Einstein's special theory of relativity. In fact, astronomers have observed this so-called "superluminal motion" from two different sources in our own galaxy as well (see "A Black Hole Erupts," AstroNews).

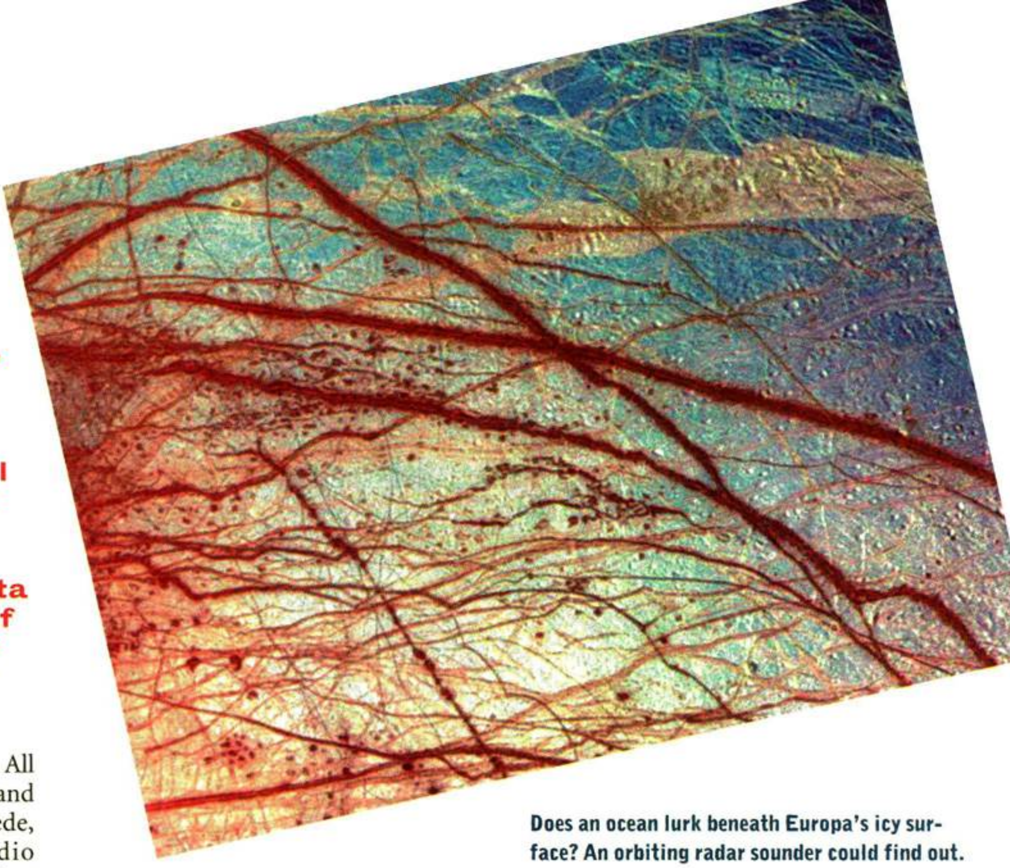
Yet superluminal motion does not concern astronomers and physicists because the effect can be easily explained. It is an optical illusion created by jet material ripping through space at near light speed at an angle almost directly toward Earth. Because of this orientation, the jet material almost keeps up with the light it emits, leading to the superluminal effect. The diagram below explains how nature can *appear* to break one of its most sacred laws without actually doing so. — *Robert Naeye*

A blob of electrons (red) emits radio waves (yellow) as it travels at, say, 93 percent the speed of light. The radio waves travel toward Earth at the speed of light.



Astronomy: Elisabeth Rowan / John Biretta (STScI)

Q: Radio telescopes have sent radar transmissions that penetrated Titan's dense atmosphere and revealed continent-sized features. Could the recently upgraded Arecibo Telescope send radar transmissions to Europa that are powerful enough to penetrate the ice crust believed to be only one or two miles thick? If so, could the data pin down the existence of liquid water beneath the ice crust? — *Harry R. Ray, Wellesley, Massachusetts*



NASA/JPL

Does an ocean lurk beneath Europa's icy surface? An orbiting radar sounder could find out.

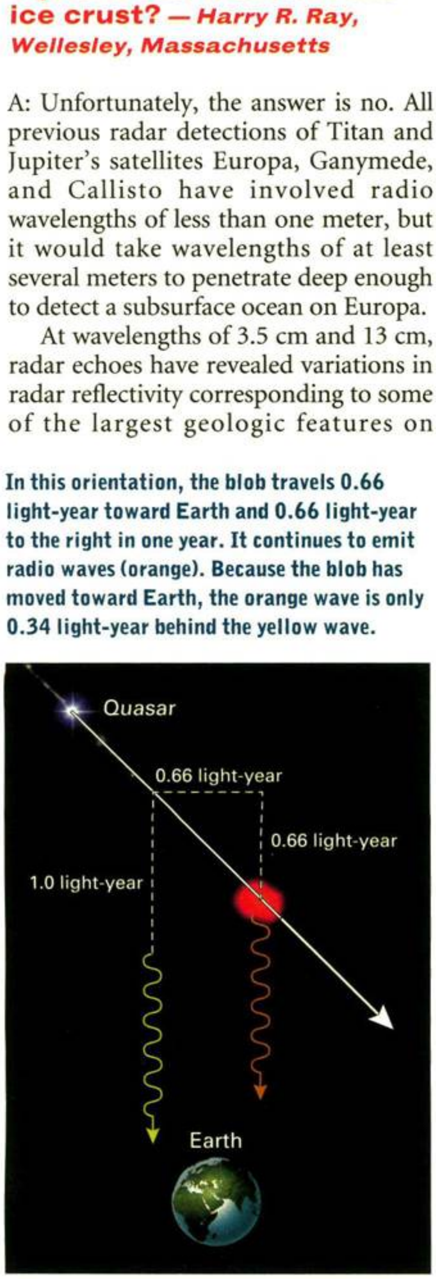
A: Unfortunately, the answer is no. All previous radar detections of Titan and Jupiter's satellites Europa, Ganymede, and Callisto have involved radio wavelengths of less than one meter, but it would take wavelengths of at least several meters to penetrate deep enough to detect a subsurface ocean on Europa.

At wavelengths of 3.5 cm and 13 cm, radar echoes have revealed variations in radar reflectivity corresponding to some of the largest geologic features on Jupiter's satellites. At these wavelengths, echoes arise from irregularities in the upper few meters of the satellites' icy surfaces, and radar brightness appears to be related to ice purity. But Arecibo observations at 70 cm indicate less backscattering, presumably because large irregularities are less common than small irregularities.

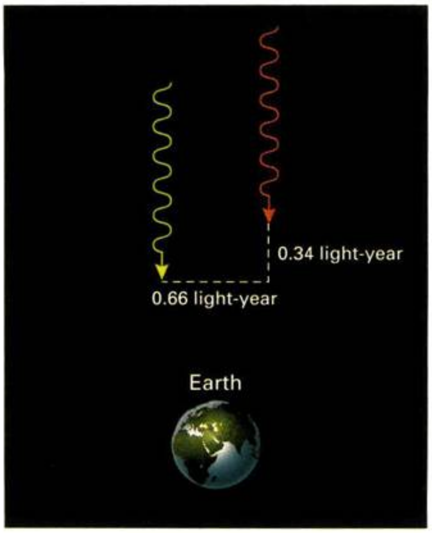
This is especially true for Europa, suggesting that meter wavelengths penetrate the surface far more efficiently than shorter wavelengths. Coincidentally, ice absorbs waves shorter than a meter much more efficiently than it absorbs waves longer than a meter. Thus, all factors considered, sounding of Europa to kilometer depths would require wavelengths of at least a few meters. Such observations are impossible with existing or planned ground-based radars.

NASA is considering the possibility of placing a long-wavelength radar sounder in orbit around Europa. Such an instrument would offer our best hope for direct detection of an ocean many kilometers underneath Europa's surface. Similarly, the Titan Radar Mapper on the Cassini spacecraft is designed to search for lakes of liquid hydrocarbons (such as ethane) on Titan. — *Steven Ostro, Jet Propulsion Laboratory* ■

In this orientation, the blob travels 0.66 light-year toward Earth and 0.66 light-year to the right in one year. It continues to emit radio waves (orange). Because the blob has moved toward Earth, the orange wave is only 0.34 light-year behind the yellow wave.



The yellow wave reaches Earth first. The orange wave arrives 0.34 year later. The blob therefore appears to have moved 0.66 light-year to the right in only 0.34 year, which is almost twice the speed of light.



CONTACT INFO

Send your questions via e-mail to: askastro@astronomy.com; or write to: Ask Astro, P.O. Box 1612, Waukesha, WI 53186. Please tell us your full name and where you live. *Astronomy* regrets that due to the large volume of mail, we are unable to publish answers to all questions or respond to each one individually.

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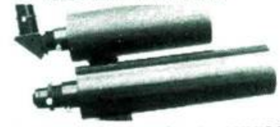

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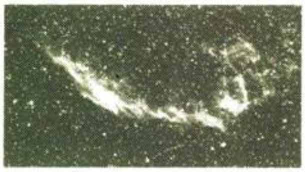

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†U.S. Patent 4,473,636

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All **LUMICON EASY-GUIDER™** off-axis guiders† have both radial and 360° rotational adjustments for 5X easier guide-star selection, use 48mm filters, 360° camera rotation, large prisms for bright guide-stars. †U.S. Patent 4,448,500
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Full aperture. Installs in seconds. Specify 2'' or 1¼''.

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5. **LUMICON EASY-GUIDER** (selection to left)
6. **LUMICON 48mm DEEP-SKY FILTER $199.50** This is essential for highest possible contrast. Contrast is boosted up to 3X for ***both*** color or black & white photos. The 3 photos in this ad showing the Helix Nebula, Horsehead Nebula and Veil Nebula were all made using a LUMICON 48mm DEEP-SKY FILTER.
7. **Hypersensitized film.** Purchase from LUMICON or make your own with a LUMICON HYPER-KIT.

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Kodak Gold 1000 fast, fine grain	12	**$13.95**
Fuji G800 fine grain color neg.	**24**	**$13.95**
Ektachrome 1600, fast slide film	24	**$14.95**
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STAR STUFF

A PRODUCTS

Equalizer Adapter

▶ The *Tele Vue Equalizer Adapter*, a solid bronze adapter weighing 12 ounces, helps solve balancing problems when switching from heavy 2-inch to lighter 1¼-inch eyepieces. It's ideal for almost any telescope with a 2-inch focuser, including Tele Vue scopes, Dobsonians, Schmidt-Cassegrains, and refractors. It allows lightweight 7mm eyepieces to match much larger ones. The adapter includes a captive lock screw and a safety undercut. Available from Tele Vue dealers, the order number is BEA-0004 Bronze Equalizer Adapter.

Tele Vue, 100 Route 59, Suffern, NY 10901; phone, (914) 357-9522. *Equalizer Adapter*: $60.

19MM PANOPTIC

Deluxe Telescope Mount

▶ KB Systems has recently begun to offer beautifully crafted polished brass and decorator wood mounts for telescopes. The mounts include a KBC2 cradle head and a KB tripod made of your choice of wood. They are engineered to provide easy, precise adjustments in both horizontal and vertical directions, and roller bearings ensure smooth operation and effortless use. The mounting surface can be adjusted to accommodate your favorite upscale telescope.

KB tripods are available in several fine woods, including eastern white ash, black walnut, mahogany, purpleheart, or teak, to match or complement your interior decor. Other exotic woods are available on request. Included with the cradle head and tripod is a KBTR10B brass tray, highly polished and clear coated, to complete the impressive assembly.

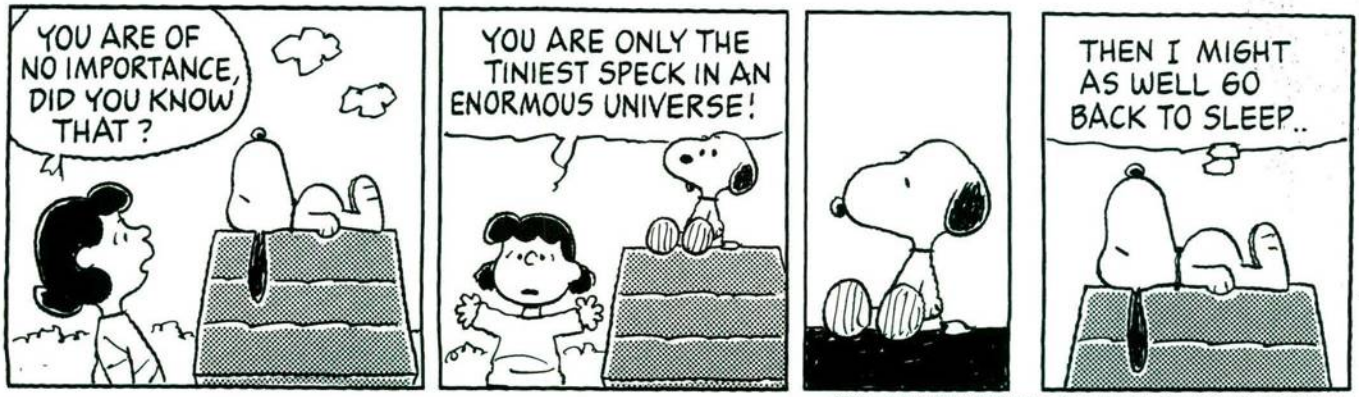
KB Systems, 10407 62nd Place West, Mukilteo, WA 98275; phone, (206) 355-8740, (800) 423-9677; fax, (206) 348-6214. *Deluxe Telescope Mount*: $1,150.

Mars Pathfinder Mission Mousepad

MARS
SURFACE
July 18, 1997

▶ Has the day-to-day routine of planting yourself in front of a computer screen for eight hours begun to wear on you? Escape to another world with this Mars Pathfinder Mission Mousepad. The familiar image taken by Pathfinder on July 18, 1997, called "The Presidential," can be a colorful place to park your mouse and an easy way to liven up your workspace. Measuring 7.5" by 9.5", the mousepad features a panoramic view of the martian desert with it's famous inhabitants Barnacle Bill and Yogi in the foreground and Couch and the Twin Peaks in the distance. Pathfinder has stopped sending images our way, so here's a way to have one that's yours to keep.

Microvision Computer Products, P.O. Box 8649, Rancho Santa Fe, CA 92067; phone, (619) 749-1805, (888) 216-1090; website, http://www.webpads.com. *Mars Pathfinder Mission Mousepad*: $8.95 plus $2 shipping.


YOU ARE OF NO IMPORTANCE, DID YOU KNOW THAT ?
YOU ARE ONLY THE TINIEST SPECK IN AN ENORMOUS UNIVERSE!
THEN I MIGHT AS WELL GO BACK TO SLEEP..

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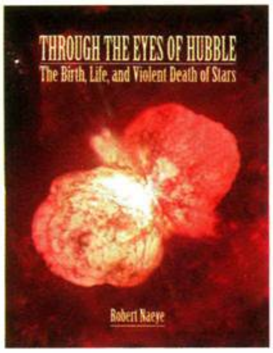
FROM THE PUBLISHER OF Astronomy®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The Birth, Life, and Violent Death of Stars
Robert Naeye

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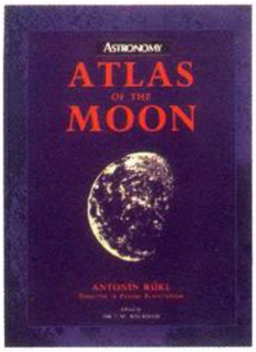

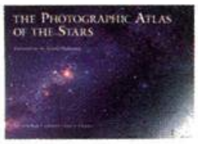

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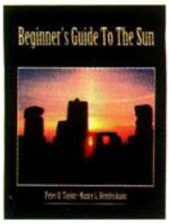

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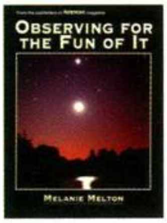

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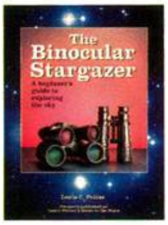

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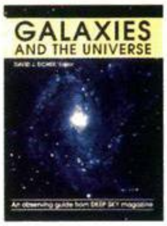

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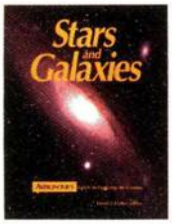

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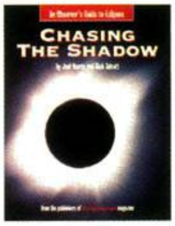

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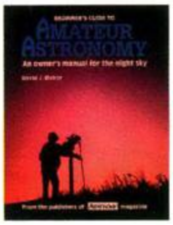

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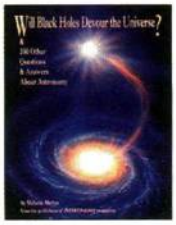

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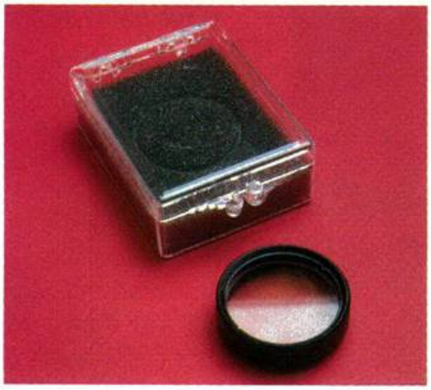
Starlight Xpress MX5 CCD Camera

▶ The new low-cost *Starlight Xpress MX5 CCD* camera from the United Kingdom uses surface mount technology to produce an extremely compact imager. Measuring just 100mm long, 50mm in diameter, and weighing seven ounces, it fits into 2-inch eyepiece holders and has a 1.25-inch adapter. Despite its size, the *MX5* is no small performer. The CCD measures 4.9mm by 3.6mm and is very blue-green sensitive. It has a 500- by 290-pixel resolution and is available in either 12- or 16-bit versions — a great value at an affordable price. An optional port will also speed up the download time.

Adirondack Video Astronomy, 35 Stephanie Lane, Queensbury, NY 12804; phone, (888) 799-0107; fax, (515) 793-9484; e-mail, 72323.3040@compuserve.com; website, http://ourworld.compuserve.com/homepages/AVAastro. *Starlight Xpress MX5 CCD* camera: 12-bit, $975; 16-bit, $1,125; shipping for each, $25.



Planetary Nebula Filter

▶ Many small planetary nebulae are hard to distinguish from stars. The *Planetary Nebula Filter* from Rainbow Optics, with its high-performance blazed diffraction grating, eliminates this problem. When the grating is screwed into a 1.25-inch eyepiece or hand-held above the eyepiece, it transforms stars into continuous, streak-like spectra, making planetary nebulae stand out because they remain isolated points of light. The filter can also be used to image spectra, both photographically and with a CCD camera.

Rainbow Optics, 1593 E Street, Hayward, CA 94541; phone, (510) 581-8266. *Planetary Nebula Filter*: $129.

BOOKS

The Life of the Cosmos

Lee Smolin, 358 pages, Oxford University Press, New York, 1997; ISBN 0-19-510837-X, hardcover, $30.

▶ At one time or another, you have likely looked around at the world and wondered why we humans are here and perhaps even how the universe we inhabit came to be. You are not alone in wondering this. Lee Smolin, professor of theoretical physics at Pennsylvania State University, ponders this question in *The Life of the Cosmos*. Light, Smolin contends, is the ultimate source of life. If this is true it means that we will never completely understand the mystery of who we are without first understanding why the universe is full of stars.

What is required for a universe to contain large quantities of carbon, oxygen, and other ingredients for life? The simple answer to this difficult question posed by Smolin: stars. Stars produce all but the lightest elements we observe in the universe. The problem: It turns out that the four fundamental forces of physics — gravity, the weak nuclear force, the strong nuclear force, and electromagnetism — must be fine-tuned to just the right values to allow for the existence of stars. In addition, the masses of the electron, proton, and neutron must be precisely set to the masses we observe, otherwise these particles would not stick together to form stable nuclei, and nuclear fusion could not occur in stars. For these reasons and others, Smolin notes that the very existence of stars could be considered something of a miracle. Within this discussion, he also writes that the whole of fundamental physics is dominated by what he calls "ridiculously small" numbers, from the gravitational constant to the masses of the elementary particles.

It seems there is a very limited range of values which the fundamental forces and the masses of elementary particles can take on and still provide for a universe with stars. How did the universe come into being if it requires such a precise tuning of the fundamental physical parameters? Smolin devotes the remainder of the book to finding an answer to this question without resorting to what he calls the mysticism of religion. Along the way, he discusses the roles played by relativity theory and quantum theory and the need to unify the two.

Smolin puts forth a number of interesting and curious ideas in hopes of finding some answers. Among these are that the physical laws are not absolute but instead evolve over time. (Fundamental physics currently assumes that all physical laws are absolute and do not depend on one's position in time or space.) Smolin observes that the conditions which exist inside a black hole are not dissimilar to the conditions before the Big Bang: extremely dense matter compressed into a very tiny region of space. Could it be that within each black hole an explosion occurs, producing yet another universe, one we can't see because the light can't escape from the event horizon? Smolin goes on to discuss a model of cosmological natural selection in which a universe exists and produces a certain number of black holes, the number of which depend on the values of the physical constants in that universe. Each black hole produced creates within itself a universe in which the fundamental physical parameters vary from its progenitor universe by a very small amount, but because the physical constants are different, it creates a different number of black holes. In time, the universes that maximize the number of black holes dominate, and it is these universes that contain life. This must be true if we are to believe that our universe is not an anomaly, i.e. one of the very few containing life.

The book was written to address a wide audience, from interested lay people to astronomers to biologists to theoretical physicists. For those who are unfamiliar with the essence of particular areas of study referred to within the text, a concise glossary covering unfamiliar terms is provided (explaining everything from acceleration to quantum gravity to string theory). The book is an exciting mix of history, philosophy, humanity, science, and speculation — a combination Smolin uses skillfully to explain his ideas. One very appealing aspect of the book is the

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Misc. Meade

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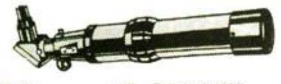

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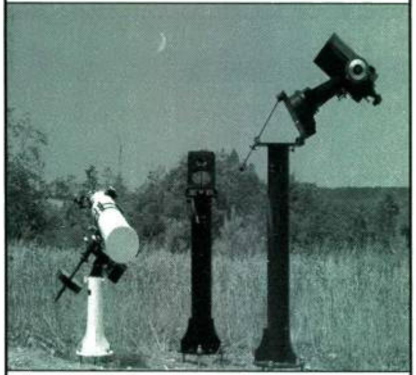

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Earth
IN THE APRIL ISSUE

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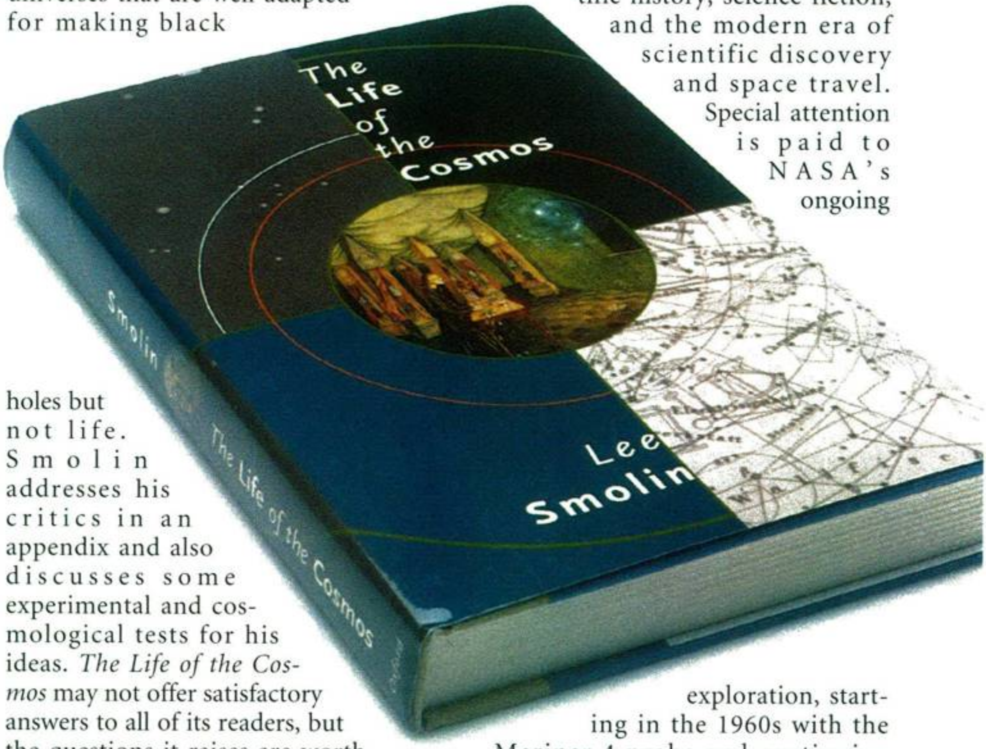
From the publishers of
Astronomy

plethora of personal anecdotes from Smolin's life, including how he became interested in science after briefly dreaming of becoming a rock-and-roll star. We get to see him as a person as well as a scientist.

In his prologue Smolin writes, ". . . what I am presenting in this book is a frank speculation, if you will, a fantasy." Smolin's ideas are not generally accepted by the scientific community at large, a fact that he freely admits. The weakest link in Smolin's theory, according to his critics, is the connection he requires there be between black holes and life. Cosmological selection, they argue, should produce plenty of universes that are well adapted for making black holes but not life. Smolin addresses his critics in an appendix and also discusses some experimental and cosmological tests for his ideas. *The Life of the Cosmos* may not offer satisfactory answers to all of its readers, but the questions it raises are worth contemplation. And the more people giving thought to these questions, the more likely it will be for the right answers to be found. — *Jennifer Birriel*



Other Books

Destination Mars, In Art, Myth, and Science

Martin Caiden and Jay Barbree with Susan Wright, 228 pages, Penguin Studio, New York, 1997; ISBN 0-670-86020-4, hardcover, $29.95.

▶ Mars, with its ominous red hue, its proximity to Earth, and its peculiar movement across the sky, has mesmerized man since antiquity. Fascination with the Red Planet dates back to the time of the great Babylonian, Chinese, and Mayan stargazers. Because it is the planet in our solar system most like Earth, whether life might exist on Mars has been a long-standing question. Two summers ago, the question of life beyond Earth came under world-wide scrutiny with the report of possible fossilized organic structures found in a martian meteorite.

Destination Mars takes a look at the perception of Mars throughout human history — in mythology, religion, astrology, folklore, early scientific history, science fiction, and the modern era of scientific discovery and space travel. Special attention is paid to NASA's ongoing exploration, starting in the 1960s with the Mariner 4 probe and continuing right up to present day with the recent Mars Pathfinder and Mars Global Surveyor missions. With more than 175 colorful illustrations and stunning photographs, *Destination Mars* offers a complete and breathtaking portrait of a planet that has long captivated earthlings. — *Jeanette Brown*

McGraw-Hill Encyclopedia of Science and Technology

Sybil P. Parker, ed., 8th edition, 20 volumes, 15,108 pages, McGraw-Hill, New York, 1997; ISBN 0-07-911504-7; hardcover, $1,995.

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▶ A substantially revised and updated new eighth edition of the *McGraw-Hill Encyclopedia of Science and Technology* claims the participation of more than 3,500 experts — including 19 Nobel Prize winners — in its publication. In many cases, the people writing the entries are "the very scientists who made the discoveries," boasts editor-in-chief Sybil Parker. The encyclopedia covers 81 major subject areas — representing every principal discipline of science and engineering — ranging from acoustics to zoology. If you have questions, seek your answers here.

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The theoretical and practical aspects of each scientific or technical discipline are expertly woven together, and extensive bibliographies cite related sources. Lastly, the eighth edition also contains a new Activities Guide, which suggests easy-to-implement ways to involve students in the excitement of learning about science. — *J.B.*

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A BYTES

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Lunar and Planetary Institute, 3600 Bay Area Boulevard, Houston, TX 77058-1113; phone, (281) 486-2139; website, http://cass.jsc.nasa.gov/ lpi.html. Price: $24.95 plus shipping. Minimum requirements: Windows 95, Windows 3.1, DOS 6.0, or Macintosh system 7.0; 8 MB RAM, 8-bit graphics, double-speed CD-ROM.

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▶Airbourne Precision Images presents *Introduction to Archeoastronomy*, a great new multimedia CD-ROM program for archeoastronomy enthusiasts. Written, researched, and produced by David Iadevaia, the program presents his impressions, as gathered through extensive on-site field work, of four well-known archeoastronomy sites.

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A.P.I., Inc., 2968 W. Ina Rd., Suite 275, Tuscon, AZ 85741; phone, (520) 544-7896; e-mail, api@rtd.com; website, http://www.rtd.com/~api. Minimum requirements: Windows 95, 16-bit graphics. ■

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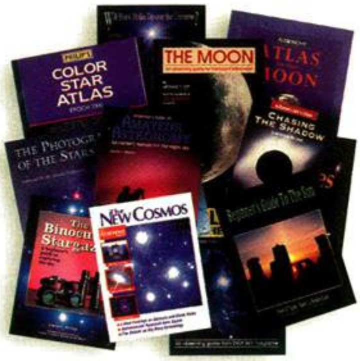

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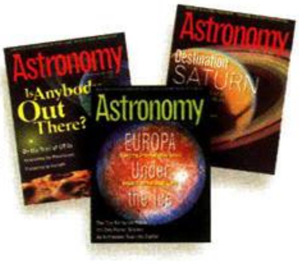

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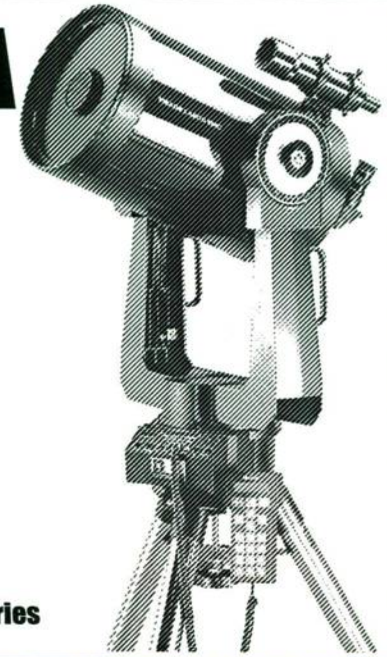

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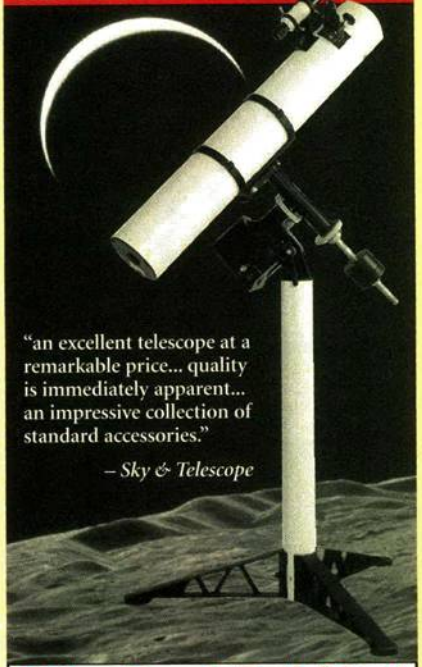

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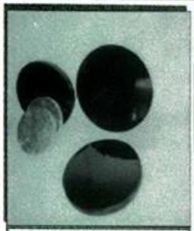

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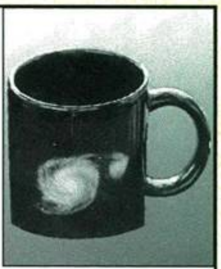

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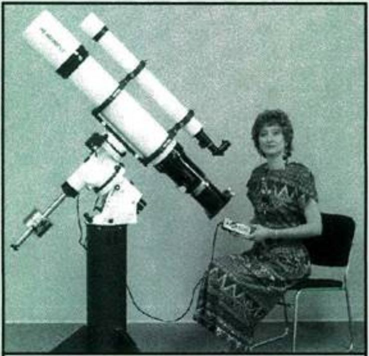

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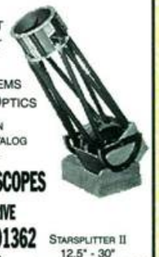

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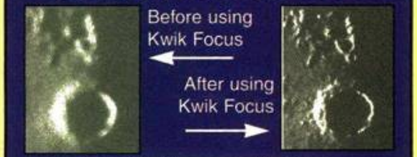

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The **Highlands Stargaze** will be held **February 26–March 1** at the Nine Mile High Campground on the Kissimmee River between Sebring and Okeechobee, Florida. This year's event will include three nights of observing under dark skies with a limiting magnitude of 6.5, great views of the zodiacal light stretching from the western horizon up to and beyond the Pleiades, and stunning views of Omega Centauri and other Southern Hemisphere objects which cannot be observed from more northerly locations.

The Museum of York County and Carolina Skygazers of Rock Hill, South Carolina, will be hosting the **Gathering at the Equinox** on Saturday, **March 21.** The featured speaker, JoAnn Joselyn of the National Oceanic and Atmospheric Administration, will be sharing the results of her research on solar cycles and their effects on Earth's satellites.

You are invited to join us in celebrating our 25th anniversary at ***Astronomy* Magazine's Very Own Star Party** taking place **June 25, 1998**, at Rio Rancho Balloon Fiesta Park, just a short drive from Albuquerque, New Mexico. This free event is for all of our friends – amateurs, professionals, and their families. Universe '98 opens the following day in Albuquerque. Mark your calendars and set your plans in motion, because we're planning a great time. To find out more about these events and others happening around the country, see *Astronomy*'s website, http://www.astronomy.com.

FEBRUARY 26–MARCH 1

Highlands Stargaze

▶ Nine Mile Grade Campground, Sebring, Florida. Contact Richard Lindblom, 2130 Gresham Street, Sebring, FL 33872; e-mail, lindblom@ct.net; website, http://www.cris.com/~Lindblom/Index. shtml.

MARCH 7

Wagman Winterfest

▶ Nicholas E. Wagman Observatory, Mahaffey Road, Deer Lakes Regional Park, Russellton, Pennsylvania. Contact Pete Zapadka, (412) 224-2510; website, http://trfn.clpgh.org/orgs/aaap.

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Lunar and Planetary Science Conference

▶ NASA Johnson Space Center, Houston, Texas. The meeting will focus on new results in planetary science. Contact LeBecca Simmons, 118 Publications and Program Services Department, 3600 Bay Area Boulevard, Houston, TX 77058-1113; (281) 486-2158; e-mail, simmons@lpi.jsc.nasa.gov.

MARCH 21

Gathering at the Equinox

▶ Museum of York County, 4621 Mt. Gallant Road, Rock Hill, South Carolina 29732. For information, send a SASE to Barbara Reynolds, Settlemyre Planetarium, at the above address; website, http://web.cetlink.net/~btcrook/GATE.htm.

MARCH 21

Vernal Equinox Sunfest

▶ 11:00 a.m. to 3:00 p.m. at the Adler Planetaruim, 1300 South Lake Shore Drive, Chicago, Illinois 60605. Contact (312) 322-0304, 24-Hour Information Line, (312) 922-STAR; website, http://astro.uchicago.edu/adler/.

MARCH 21–22

Telescope/Optics Workshop

▶ Saturday, 8:00 a.m. to 9:00 p.m., and Sunday, 8:30 a.m. to 4:00 p.m. at the Math/Science Building, Western Washington University, Bellingham, Washington. Contact Kreig McBride, 402 East Horton Road, Bellingham, WA 98226; (360) 671-1665; website, http://www.wwu.edu/~skywise/optics.html.

MARCH 26–29

Peach State Star Gaze

▶ Camp McIntosh, Indian Springs State Park, Jackson, Georgia. Contact Ken Poshedly, 3440 Everson Bay Court, Snellville, GA 30278; (770) 979-9842; e-mail, ken.poshedly@mci2000.com.

MARCH 27–28

Astro-Observer's Weekend

▶ Pine Mountain State Resort Park, 1050 State Park Road, Pineville, Kentucky 40977. The registration fee is $20, and the pre-registrations deadline is March 13. Contact Dean Henson, above address; (606) 337-3066.

MARCH 27–28

Free Public Star Party

▶ Lemon Lake County Park, 6322 West 133 Avenue, Crown Point, near Cedar Lake, Indiana. Contact Terry Stage, (219) 662-9290.

MARCH 27–30

Australian CCD Workshop

▶ Grove Creek Observatory, Trunkey Creek, New South Wales, Australia. Contact Steven Williams, Grove Creek Observatory, CCD Workshop, Unit 16, 1–5 Stokes Street, Lane Cove, NSW 2066, Australia; e–mail, stevew@gco.org.au.

Red Planet Rendezvous (page 50) **and Seeing More on Mars** (page 61)

Images from the Mars missions can be found on the following websites: http://www.jpl.nasa.gov/marsnews/img/; http://mpfwww.jpl.nasa; http://www.msss.com/mars/global_surveyor/camera/images/index.html; and *Astronomy*'s website, http://www. astronomy.com.

The Planet Mars: A History of Observation & Discovery, by William Sheehan, (University of Arizona Press, 1996). A thoroughly enjoyable history of Mars exploration, from the pre-telescopic era to Viking and beyond.

Mars: The Story of the Red Planet, by Peter Cattermole, (Chapman & Hall, 1992). A comprehensive, semi-technical overview of humanity's knowledge of the Red Planet prior to the Pathfinder and Surveyor missions.

The Surface of Mars, by Michael Carr, (Yale University Press, 1981). A thorough discussion of Mars, written by a leading planetary scientist. This book is richly illustrated with black-and-white photos.

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Seeing into Violent Corners (page 82)

Millenium Star Atlas, by Roger W. Sinnott and Michael A. C. Perryman (Sky Publishing Corp. and European Space Agency, 1997). A magnificently detailed new star atlas that contains all of the objects mentioned in the article and thousands more.

Stars and Galaxies, edited by David J. Eicher (Kalmbach Publishing Co., 1992). A tour of 344 deep-sky, high-energy objects, this book contains numerous observing hints, charts, and maps for looking at the Milky Way and other galaxies.

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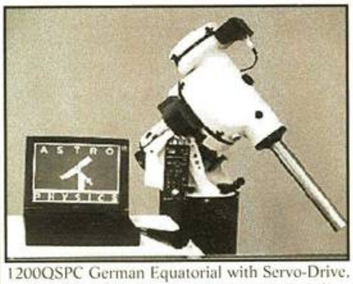

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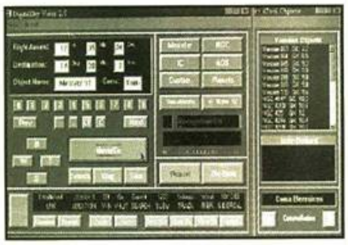

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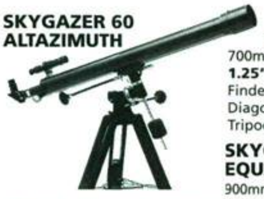

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AD INDEX

ASM Products .110
Adirondack Video Astronomy .109
Adorama .116, 117, 129
Alien Tourist Co. .110
Analytical Scientific .118, 129
Arcron Zeit .22
Astro-Physics .110, 115
Astronomics .18, 23, 110
Astronomy By Hand .111
Astronomy Shoppe .118, 129
Astrosystems, Inc .112
Augen Optics .108
Ball Photo Supply .118
Beigle/Bryant Engineering .112
Bergen County Camera .129
Berger Brothers Camera Exchange .118
Bethany Sciences .113
Blue Sky Pages .118, 119
Bose Corp .25
Bruce Johnston Computing .112
CC Sales/Camera Corner, Inc. .129
California Telescope Co. .108
Camera Bug .118, 129
Dr. Paolo Candy .108
Captain's Nautical Supplies .129
Michael I. Casper Meteorites .108
Celestron International .35, 132
DGM Optics .110
Dark Matter Images .110
Day Star .27
Descartes & Associates .108
Dover Photo Supply .129
Eagle Optics .119, 129
Earth & Sky Adventure Products .111
Eastman Kodak Co. .31
Edmund Scientific Company .17
Edward R. Hamilton, Bookseller .111
Efstonscience, Inc. .119
FC Meichsner Company .31, 129
Focus Camera .80, 81
General Exhibits & Display .20
International Optics Ltd .112
Internet Telescope Exchange .112
Into the Wind/The Kite Source .113
JMB Inc .31
Jack Schmidling Production, Inc. .110
Jim Kendrick Studios .109, 113
Jim's Mobile Industries .47
Kalmbach Publishing Company .27, 34, 99, 102, 103, 106, 107, 119, 120
Khan Scope Centre .119
Kitt Peak National Observatory .21
Knollwood Books .112
Labenne Meteorites .112
Lasermax, Inc. .112
Lesueur Manufacturing Co. .102
Lumicon .96, 97, 129
Marketplace Pages .108, 109, 110, 111, 112, 113
Meade Dealer Pages .14, 15
Meade Instruments Corp .2, 3, 7, 8, 9, 10, 11, 12, 13
Minerva Press .110
Mountain Skies Astronomical Society .108
Murnaghan Instruments .27
Mystic Stamp Company .29
Neptune Photo .118
New England Meteoritical .113
New Mexico Astronomical .118
Newbridge Communications .19
Newport Glass Works .108
Nisur Systems .109
Novagraphics .109
Nurnberg Scientific .118
Oceanside Photo & Telescope .18, 129
Orb Publishing .111
Orion Telescopes & Binoculars .33
Pocono Mountain Optics .37, 38, 39, 129
Practically Mobile .109
QSP Optical Technology, Inc. .108
Radio City .113
Rainbow Symphony .48, 111
Rex's Astrostuff .113
Rivers Camera Shop .69
Santa Barbara Instrument Group .68
Sarasota Camera Exchange, Inc. .118
Science Connection, Inc. .111
Scope City .18, 129
SETIQuest .110
Shutan Camera & Video .101
The Sky is Falling, LLC .69
Sky Optics .119
Software Systems Company .27
Sovietski Military Connection .109
Spectra Astro-Systems .22
Starsplitter Telescopes .109, 112
Stellar Structures .111
Stellar Vision .118, 129
Surplus Shack .113
Tech 2000 .113
Technical Innovations .31
Tele Vue Dealer Page .129
Tele Vue Optics, Inc .130, 131
Telescope & Binocular Center .92, 93
Thousand Oaks Optical .29
Travel Quest .109
Travel Wizard .112
Roger W. Tuthill, Inc. .20, 22, 108
University Optics, Inc. .20
Vernonscope .113
Virgo Astronomics .113
What in the World .29
Wholesale Optics .105
Zephyr Services .112

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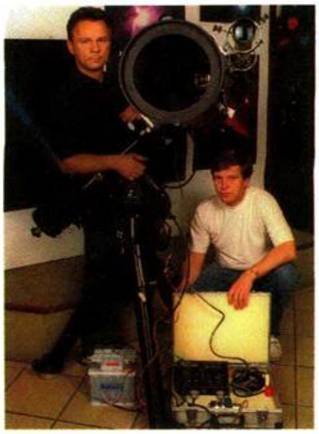
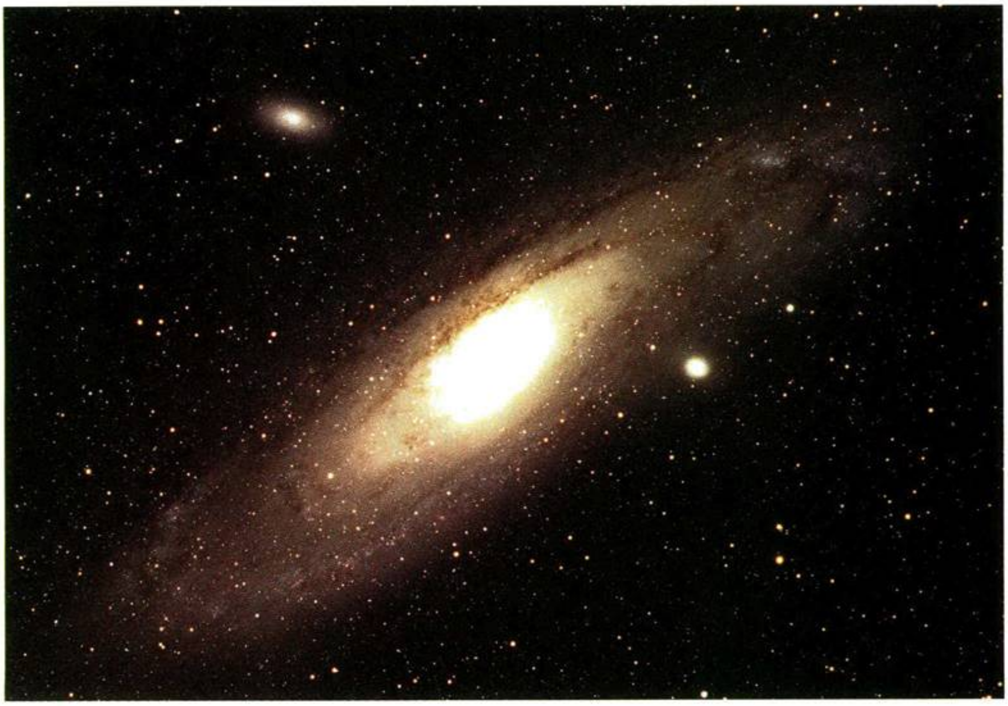
▶ Poor viewing conditions in much of Austria send most amateur astronomers away from their homes in search of dark skies. We live in Vienna, the country's capital, where the 1.5 million inhabitants create considerable light pollution. Driven by our interest in deep-sky astrophotography, we travel to darker regions outside the city called the Voralpen, reachable by a an hour-long journey by car.

In the Voralpen, observing conditions are excellent because the region is sparsely populated. The sites we frequent range from 1,800 to 5,100 feet above sea level, out



Star Stalkers

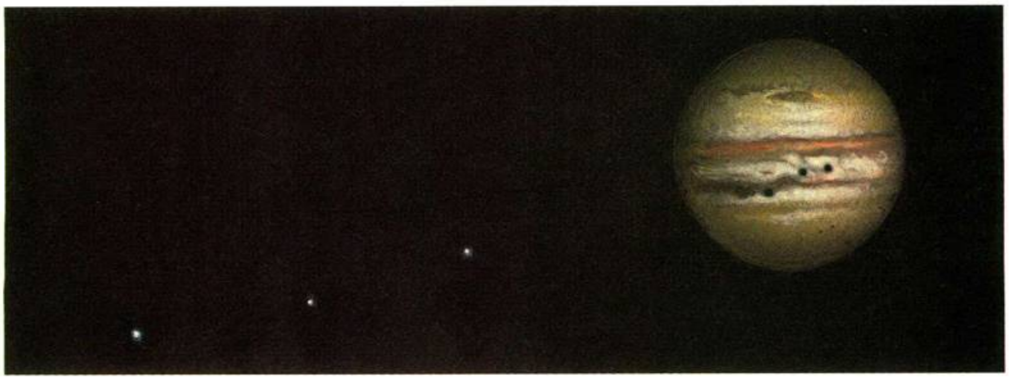
Gerald Rhemann (left) and Franz Kersche display their Schmidt camera and other astrophotography paraphenalia. The fruits of their passion, stunning photographs they've taken over the last few years, are displayed on the wall behind them.



The Andromeda Galaxy (M31)

GERALD RHEMANN AND FRANZ KERSCHE

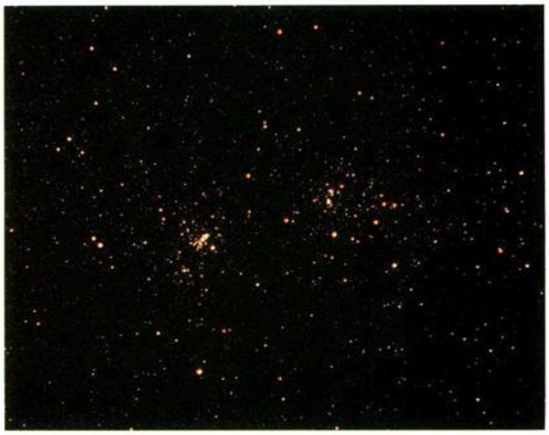
(6-inch f/7 refractor, Kodak PPF 400 film, composite of two 70-minute exposures)



Moon Shadows Dance across Jupiter

JON M. SCHWARTZ

(Acrylic painting of jovian moons casting shadows on Jupiter, 11-inch f/10 SCT, November 10, 1997, 9:45 p.m. PST)



The Double Cluster in Perseus (NGC 869 and NGC 884)

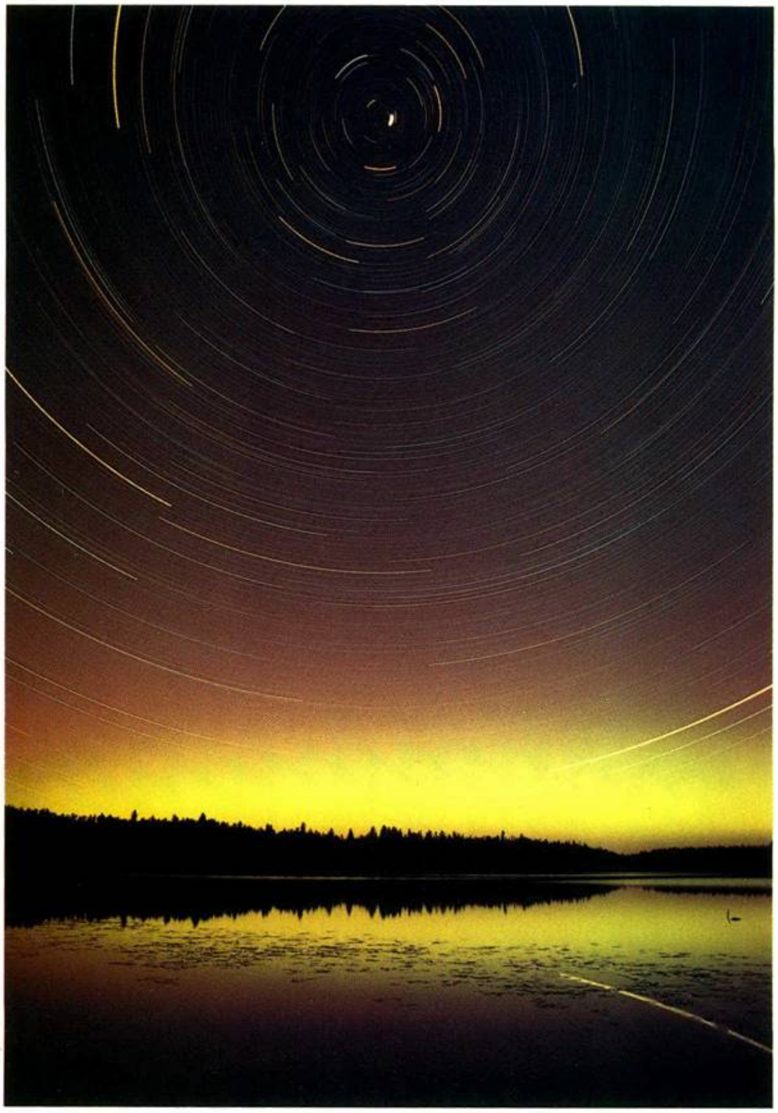
PHILIPPE DURVILLE

(9-inch f/3.9 reflector, Kodak Gold 400 film, 45-minute exposure) of fog's reach in autumn and winter. Clear winter nights boast naked-eye limits of about magnitude 6.5, sometimes drawing closer to 7th magnitude. Due to our northern latitude of 48°, it is frequently possible to capture the Milky Way's splendors down to a declination of –28° on color film. These factors are compromised, however, by the fact that there are only five clear nights on average in the times of the new moon. So we are forced to head out even when weather conditions are unsteady, hopeful that clouds will dissipate.

We use a wide range of equipment for our astrophotography. One of our favorite instruments is a 10-inch f/2 Schmidt camera driven on a Losmandy G-11 mount and guided with a 60mm refractor. To obtain the best focus, we've found it necessary to push the film against the curved back plate of the filmholder using a pump; a darkroom tent set up in the back of our car provides a place to load the filmholder (we most often use medium format 6x6 cm film).The Schmidt camera gives us short exposure times, ranging from 5 to 12 minutes, and a wide field of view, making it a perfect comet-catcher. Capturing comets photographically is one of our greatest goals, so you see why this instrument ranks so high on our lists.

For work with refractors, Kodak Pro Gold 400 film has served us well, and sandwiching (stacking negatives) is the method we most prefer. We take two shots of the same object, one 70-minute exposure using the refractor and one 8-minute exposure using the Schmidt camera and Kodak Pro Gold 160 film.

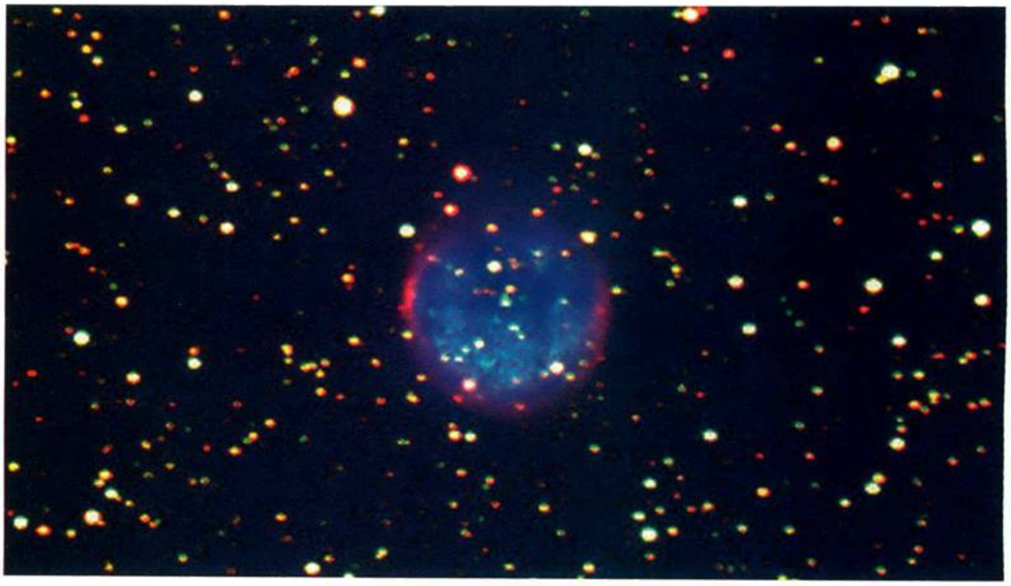
Years of practice and skilled procedures enable us



Star Trails Canadian-Style

JOSEPH MAROHNIC

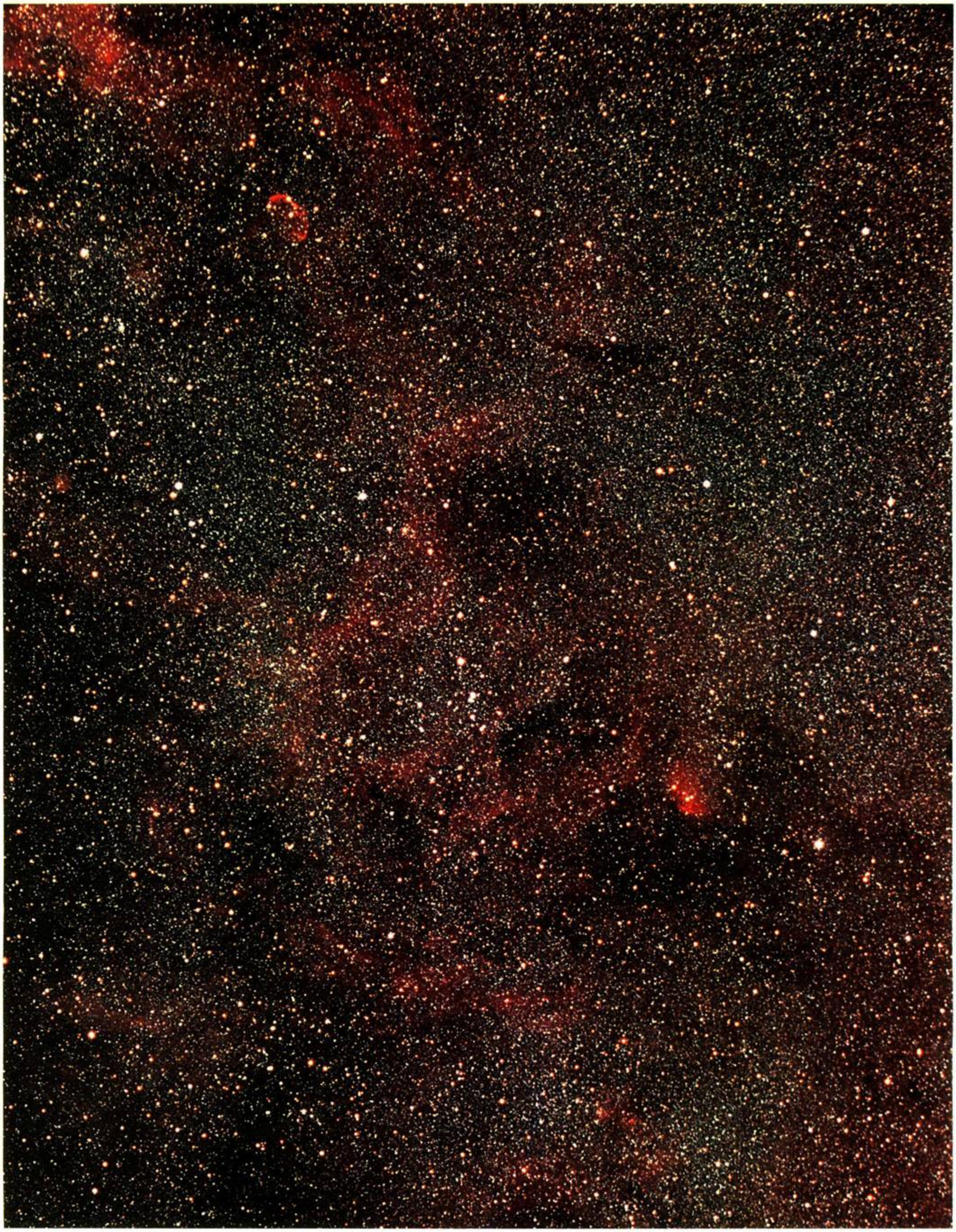
(24mm lens at f/5.6, Kodak PJM-2 film, 155-minute exposure taken July 30, 1997, in Ontario, Canada)



Faint Planetary Nebula NGC 6781 in Aquila

JACK NEWTON

(16-inch f/10 SCT, Pictor 1616XT CCD camera, composite of 10-minute red, 20-minute green, and 20-minute blue exposures)



Emission Region Southwest of NGC 6888 in Cygnus

GERALD RHEMANN

(6.7-inch f/1.5 Schmidt camera, hypered Kodak Ektar 25 film, composite of 15-minute and 20-minute exposures) to set up quickly, despite our heavy equipment. A quick setup is one of the most crucial requirements for capturing comets in the evening sky.

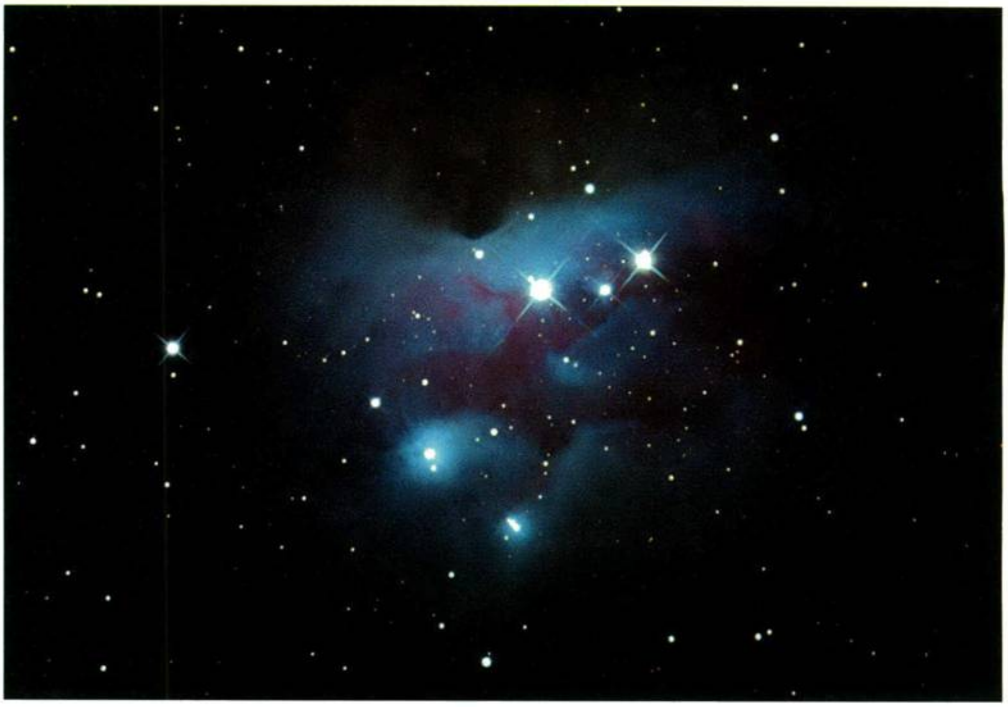
Though our passion is certainly photography, we find time for visual astronomy as well. For extended viewing we use an ST-4 autoguider, 30x80 binoculars, or a 10-inch Dobsonian scope and can get swept away by the beauty of the heavens.

After the observing run is over and the pictures have been shot, we set to work processing the film. The most important element to processing perfect color pictures is knowledge of advanced darkroom techniques. Here are a few of our tricks and procedures. If you put them to work, you're bound to achieve really neat pictures for yourself.

We use negative emulsions exclusively. After stacking the negatives, several additional steps are often necessary to get good contrast. In some cases, we first produce slides, then internegatives, and finally prints. For many of our best photographs, much more time is spent in the darkroom than under dark skies.

An exquisite astrophoto is the result of a delicate and precise combination of skilled observing and practiced processing skills, and our plan is to keep working toward perfection. Give it a shot yourself — the impressive results will surprise you. A

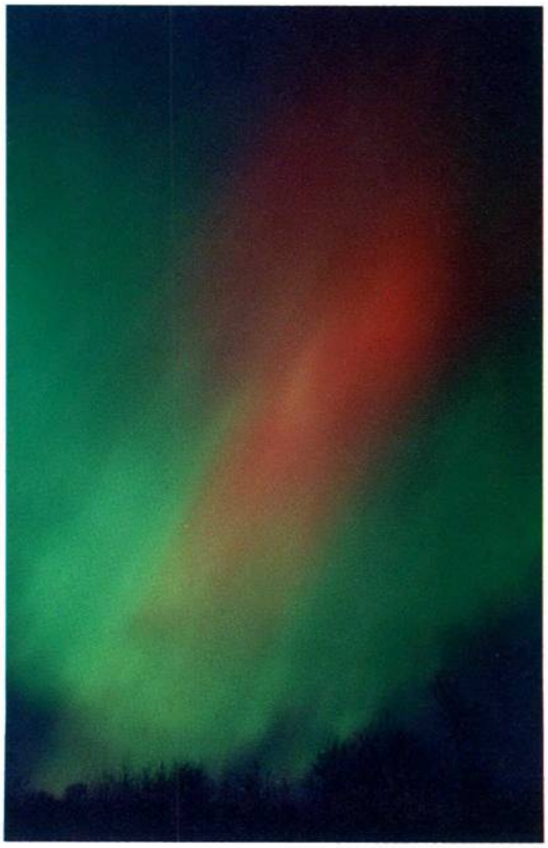
The photographs of Gerald Rhemann and Franz Kersche, amateur astronomers from Vienna, Austria, have appeared in Astronomy *in past issues. Gerald also owns a professional photoshop in Vienna specializing in astrophotography.*



Drippings from Orion's Sword (NGC 1973-75-77)

ANDREW PETERS

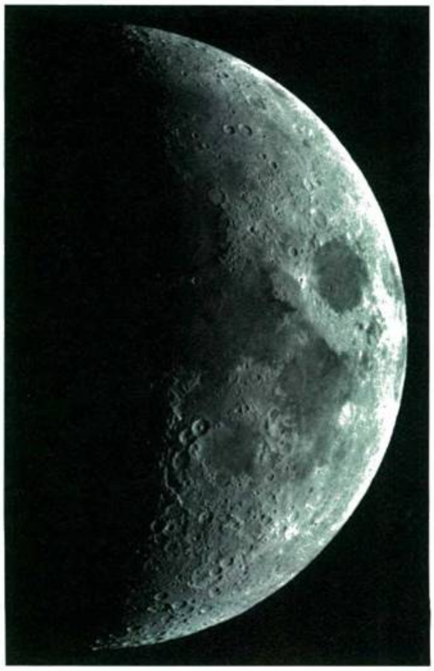
(20-inch f/5 reflector, Kodak Pro 400 film, 105-minute exposure)



Aurora in Northeastern Wisconsin

MONTY MONTGOMERY

(28mm lens at f/2.8, Kodak Gold 100 film, 45-second exposure taken November 8, 1991)



Waxing Crescent Moon

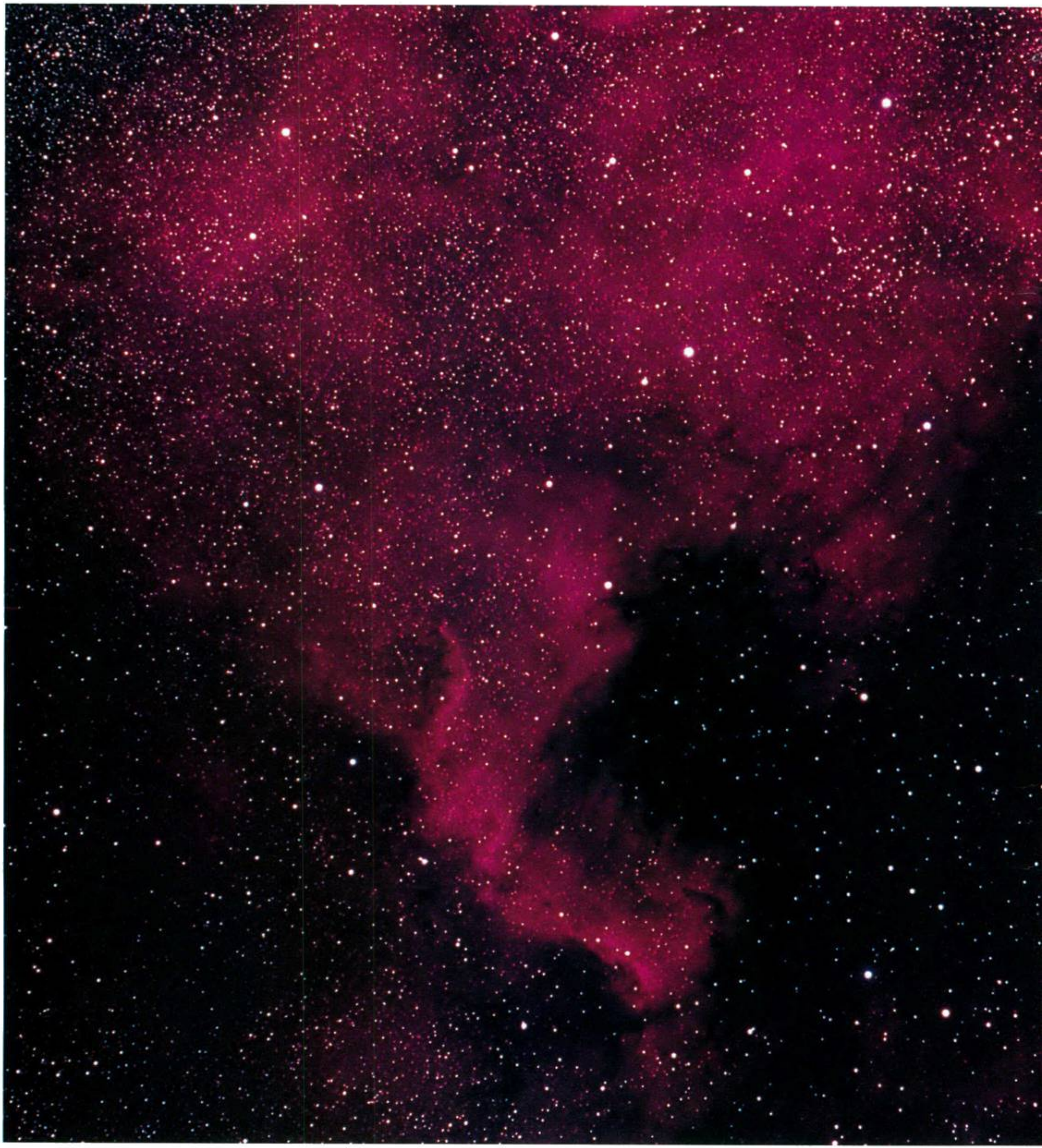
DAVID HANON

(7-inch f/6 refractor, ST-8 CCD camera, 0.11-second exposure through stacked red and blue filters, taken February 24, 1996)

The Caterpillar Leaves a Trail to its Cocoon (IC 5146 and Barnard 168)

CARL AND CHRIS WEBER

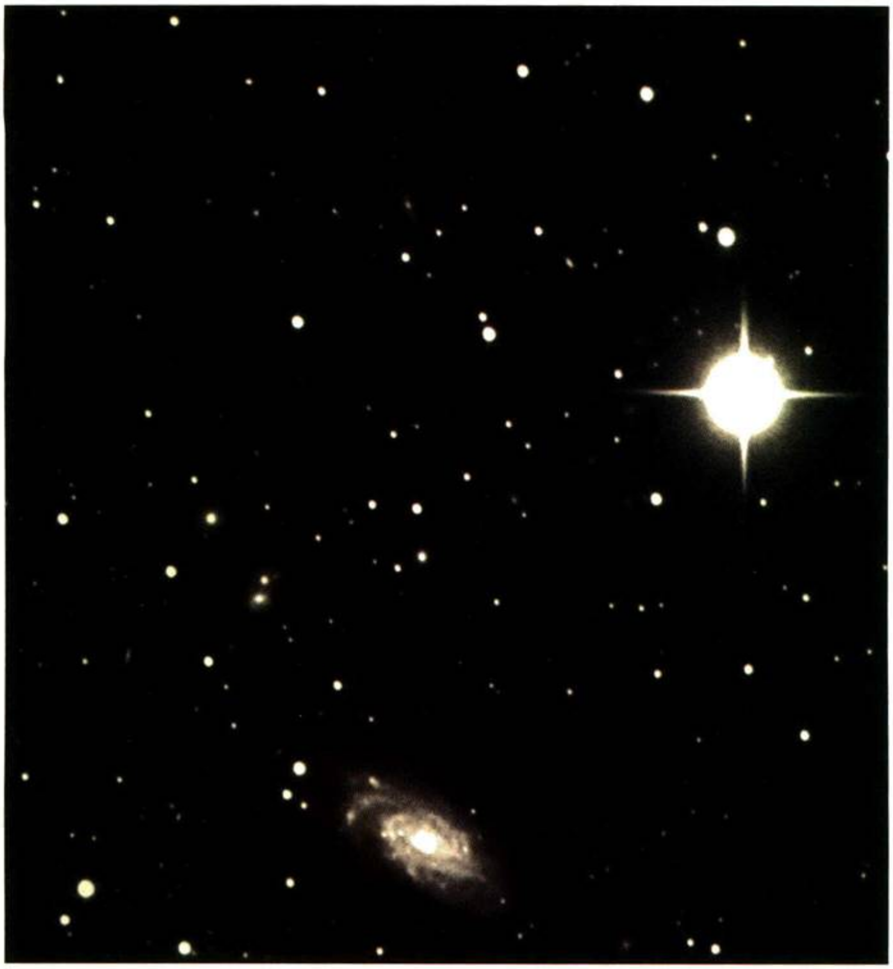
(6-inch f/7 refractor, 120 format Kodak Pro 400 PPF film, composite of two 50-minute exposures)



The North America Nebula (NGC 7000) in Cygnus

W. A. TREMBLY, JR.

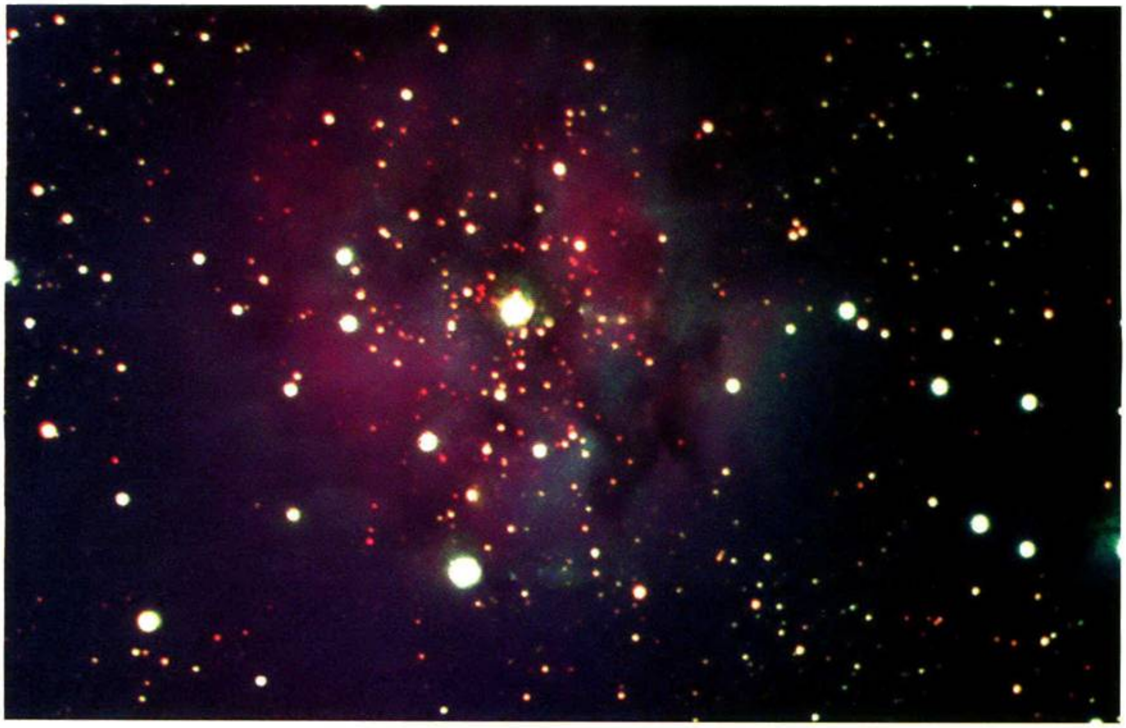
(6-inch f/7 refractor, Kodak PPF 400 film, composite of 60-minute and 30-minute exposures)



NGC 6070 in Serpens Caput

MARTIN C. GERMANO

(14.5-inch f/5 Newtonian, hypered Kodak Tech Pan 2415 film, 120-minute exposure)

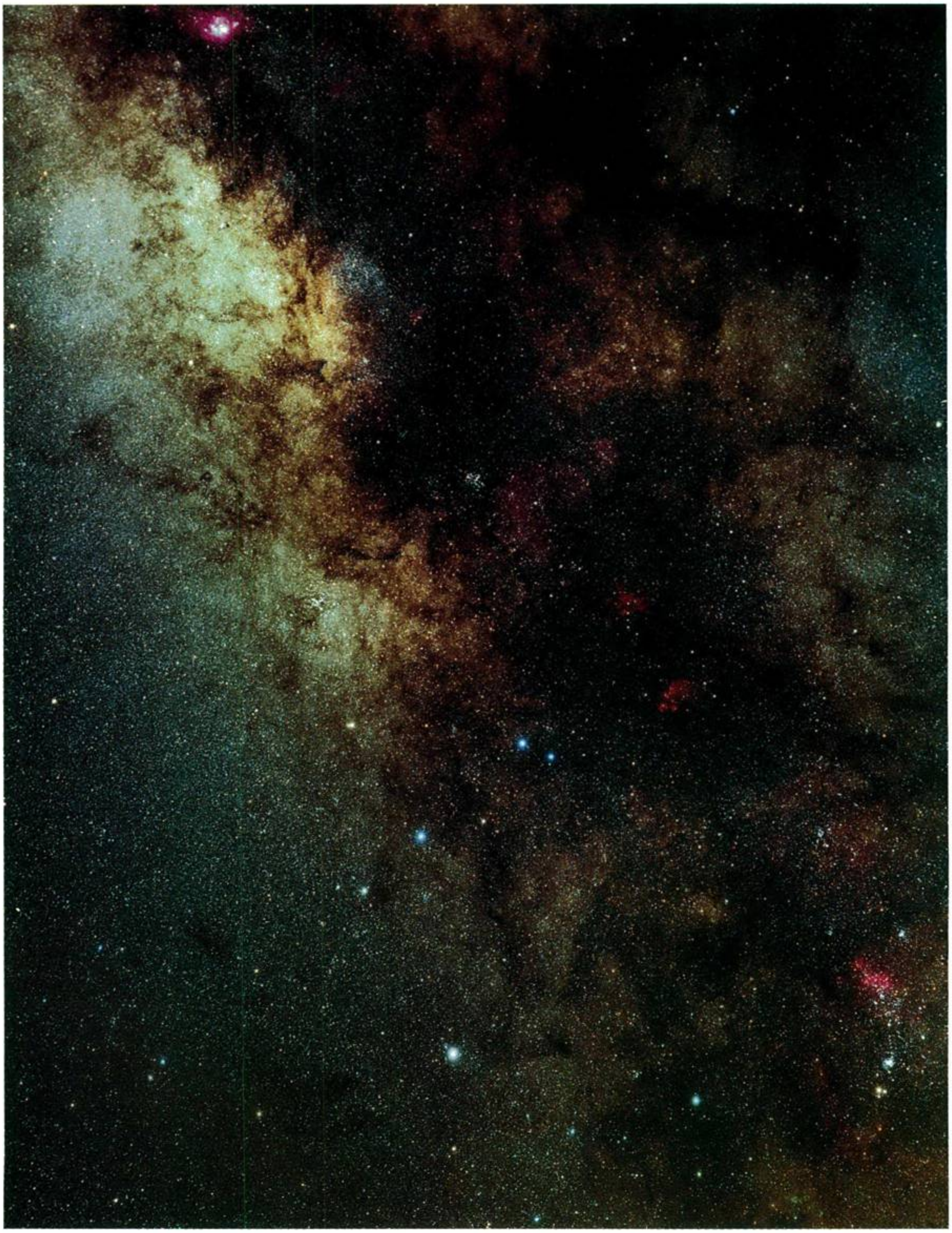


The Cocoon Nebula (IC 5146) in Cygnus

JACK NEWTON

(16-inch f/10 SCT at f/6.2, Pictor 1616XT CCD camera, composite of 10-minute red, 20-minute green, and 20-minute blue exposures)

This month's best astrophoto



Galactic Splendors

CARL AND CHRIS WEBER

(165mm lens at f/5.6, 120 format Kodak PPF Pro 400 film, composite of two 25-minute exposures) This stunning shot of the region of the galactic center illustrates the dark *obscuring material* at the center of our galaxy. This celestial gallery begins with the Lagoon Nebula (M8) at the top left and captures deep-sky objects in Sagittarius before ending up in southern Scorpius.

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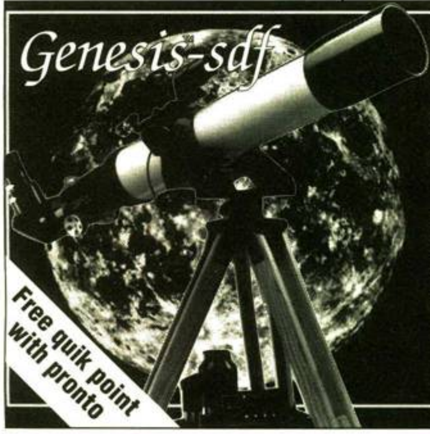

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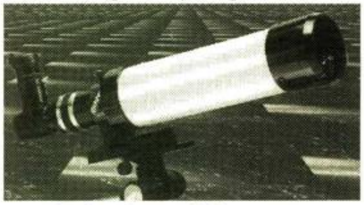

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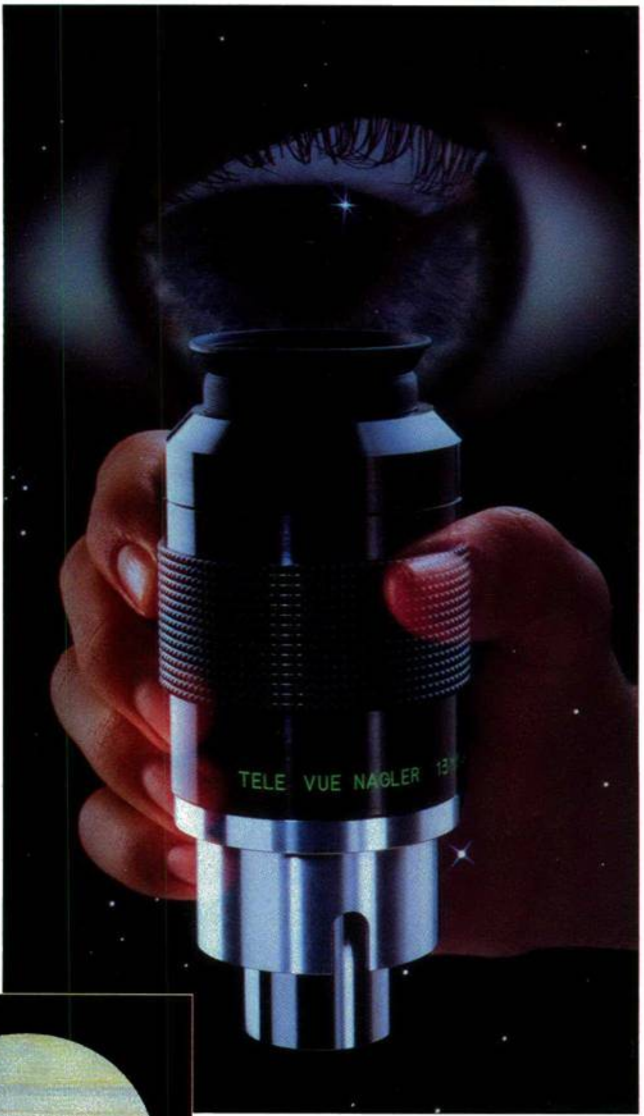
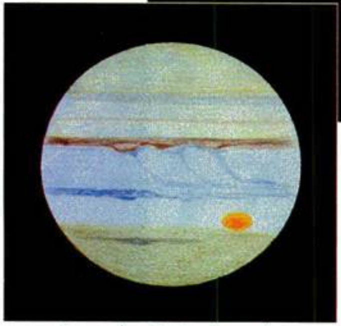
Dear Mr. Nagler,

"I thought it long overdue that I write to give my impressions of your Nagler eyepiece designs. *I say 'long overdue,' because I bought my first Nagler (a 7mm) back in 1984. The reason for the purchase was that earlier that year I had invested in a Celestron C-11 and a 4" Fluorite, F/9 refractor. I thought that the stated objectives of the Nagler design — long eye-relief and a wide, highly corrected field of view, would exploit the full potential of a telescope with 2,800mm focal length, and the imaging capacities of a fine refractor. I was not disappointed. Soon after came the fantastic 9mm and 11mm Naglers and then the 4.8mm for the refractor.*



These eyepieces have given me my most rewarding hours spent at the telescope. *My main interest is in the planets which I draw and give lectures on at our local school and observatory. The observation of the planets requires painstaking hours spent at the eyepiece. The Naglers suit my purposes exactly.*


Drawn by Mr. Toohey with 12 N2

When the Type 2s were introduced onto the market I could not resist them. I purchased the 16mm and 12mm models. The 20mm seemed too large, heavy and costly, so I left it alone. These were the same reasons for not buying the 13mm (apart from the fact that by then I owned a 12mm Type 2). However, earlier this year, after years of looking through other people's 13mm and 20mm Naglers, I finally decided to take the plunge myself. ***So now I own a full set of Naglers*** *(including the wonderful 11mm which despite many offers, I will not part with).*

When I remember what eyepieces for the amateur market were like before the introduction of the Naglers (like looking down a drain pipe, or 60° fields, with astigmatism and severe edge of field aberrations), ***it is clear that your designs have taken us a quantum leap forward. No other eyepieces, in the Naglers' range of focal lengths, satisfy me now.***

Many of my fellow planetary observers say that conventional field eyepieces are sufficient. In a way they are right; good Plössls, for example, produce superb images. However, I believe the extra eye-relief, the huge field of the Naglers, coupled with marvellous image correction and the impression that ***the telescope simply gets out of the way,*** *all add up to a delightful psychological difference when using the Naglers. One feels more involved, more present to what one is viewing.*

Over the years I have found that amateur astronomers can be fairly stubbourn people in somehow defending their choice of equipment. Next thing you know they upgrade what was once, in their view, the very best available. ***Only good products stand the test of time. For me, the Naglers are such a product.*** *Not only have they remained with me; I have kept buying more of them!*

To some extent, astronomy, and particularly amateur astronomy, is about emotion and the involvement of the imagination. ***I have to say that Nagler eyepieces have captured my imagination.*** *As well as giving pride of ownership, Naglers are immensely satisfying and a joy to use.*

The little instruction sheet that comes with the eyepieces says that you wish the user 'years of exciting viewing with these eyepieces, and welcome comments on your experiences with them.' So you asked for it. After a decade of superb images (many of which remain etched on my memory; most of which I have recorded on paper) I felt it timely to share my comments and to thank you for your contribution to amateur astronomy."

Yours Sincerely.
Christopher A Toohey

Christopher Toohey, Australia

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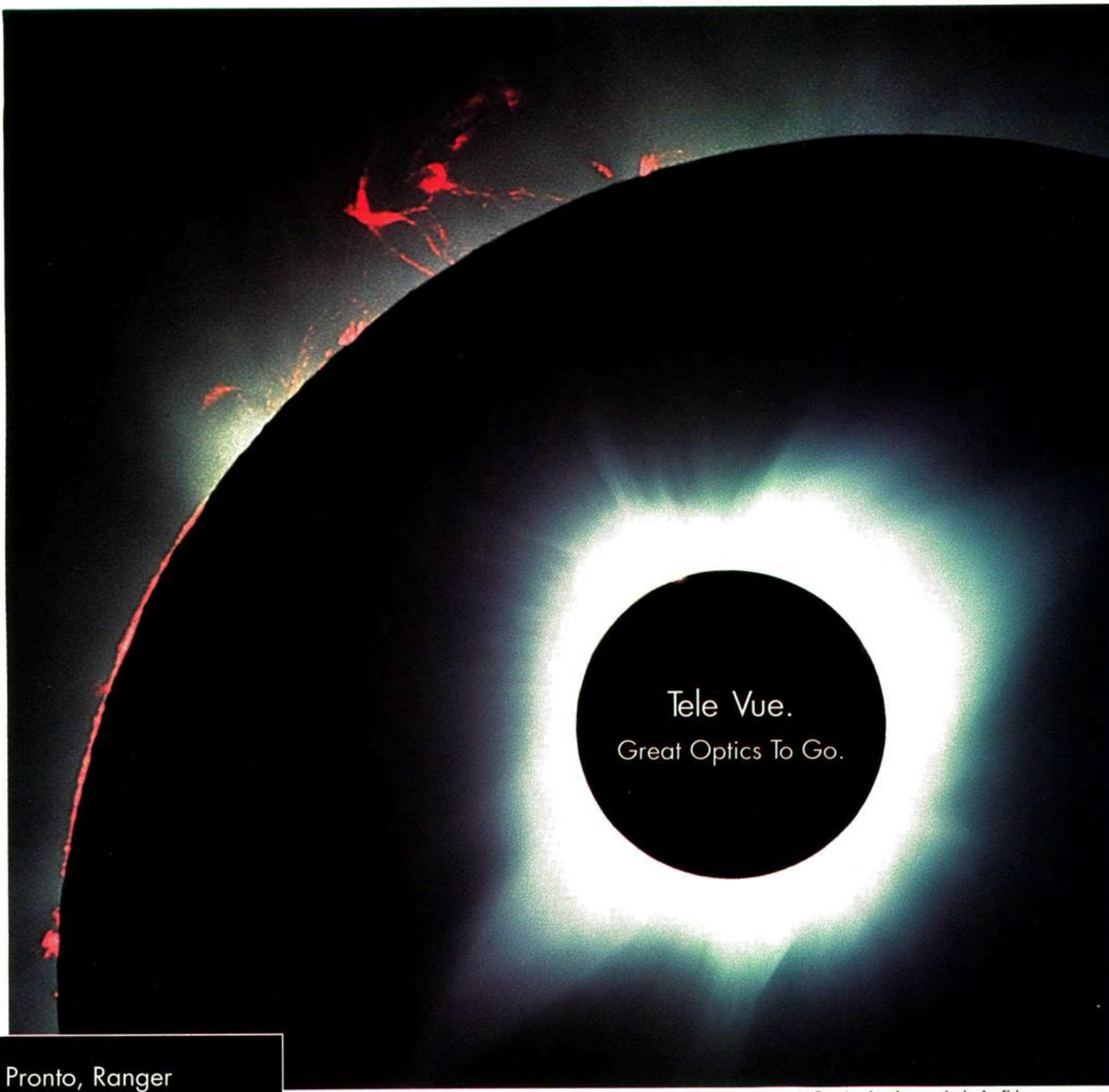

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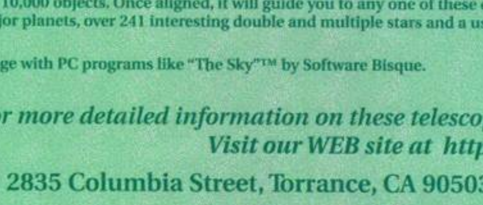

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